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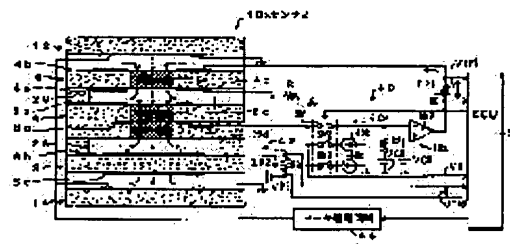
(54) METHOD AND APPARATUS FOR MEASURING OXYGEN CONCENTRATION AND NITROGEN OXIDE CONCENTRATION

(57)Abstract:
PROBLEM TO BE SOLVED: To correctly measure concentrations of NOx and oxygen by a single NOx sensor.
SOLUTION: The apparatus comprises a first measurement chamber 20 communicating with a gas to be measured via a diffusion-controlled layer 4d and a second measurement chamber 26 communicating with the first measurement chamber 20 via diffusion control layers 6d, 22d. A first pump cell 4 and a Vs cell 6 are formed in the first measurement chamber 20. A second pump cell 8 is formed in the second measurement chamber 26. An oxygen concentration and an NOx concentration are measured with the use of an NOx sensor 2 having the first and second measurement chambers. A first pump current IP1 is controlled so that an output of the Vs cell 6 becomes a reference voltage VC0, thereby controlling the interior of the first measurement chamber 20 at a constant low oxygen concentration. Moreover, a constant voltage is impressed to the second pump cell 8 thereby to decompose NOx components in the second measurement chamber 26 and extract oxygen. The NOx concentration and oxygen concentration are measured from a second pump current IP2 and the first pump current IP1 respectively. At the measurement time, a sensor temperature is detected from an internal resistance of the Vs cell, thereby to control the amount of a current supplied to the heaters 12, 14. The sensor temperature is thus maintained constant.



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* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] The 1st test chamber which has the 1st oxygen pumping cel and oxygen density measurement cel of oxygen ion conductivity which come to insert a solid electrolyte layer with a porous electrode, and was opened for free passage through the 1st diffusion limitation layer at the measured gas side, While having the 2nd oxygen pumping cel which comes to insert the solid electrolyte layer of oxygen ion conductivity with a porous electrode and having said 1st test chamber and the 2nd test chamber opened for free passage through the 2nd diffusion limitation layer The NOx sensor equipped with the heater which heats said each cel to predetermined activity temperature is used. Are the measuring method which measures the oxygen density and nitrogen-oxides concentration in measured gas, and a current is passed in said 1st oxygen pumping cel so that the output voltage of said oxygen density measurement cel may serve as constant value. By impressing a fixed electrical potential difference in the direction which pumps oxygen out of said 2nd test chamber in said 2nd oxygen pumping cel, while controlling uniformly the oxygen density of said 1st measurement interior of a room The oxygen density and the nitrogen-oxides density measurement approach characterized by measuring the nitrogen-oxides concentration in measured gas from the current value which flows in said 2nd oxygen pumping cel, and measuring the oxygen density in measured gas from the current value which flows in said 1st oxygen pumping cel.
[Claim 2] The oxygen density and the nitrogen-oxides density measurement approach characterized by controlling the energization to said heater in a measuring method according to claim 1 so that the temperature of the oxygen density measurement cel in said NOx sensor may turn into predetermined target temperature.
[Claim 3] The oxygen density and the nitrogen-oxides density measurement approach characterized by carrying out temperature compensation of each measurement result in a measuring method according to claim 2 according to the gap from said target temperature of the temperature of said oxygen density measurement cel by amending the measurement result of said oxygen density and said nitrogen-oxides concentration.
[Claim 4] The 1st test chamber which has the 1st oxygen pumping cel and oxygen density measurement cel of oxygen ion conductivity which come to insert a solid electrolyte layer with a porous electrode, and was opened for free passage through the 1st diffusion limitation layer at the measured gas side, While having the 2nd oxygen pumping cel which comes to insert the solid electrolyte layer of oxygen ion conductivity with a porous electrode and having said 1st test chamber and the 2nd test chamber opened for free passage through the 2nd diffusion limitation layer The NOx sensor equipped with the heater which heats said each cel to predetermined activity temperature is used. Are the measuring device which measures the oxygen density and nitrogen-oxides concentration in measured gas, and a current is passed in said 1st oxygen pumping cel so that the output voltage of said oxygen density measurement cel may serve as constant value. The pump current control means which controls uniformly the oxygen density of said 1st measurement interior of a room, A constant-voltage impression means to impress a fixed electrical potential difference in the direction which pumps oxygen out of said 2nd test chamber in said 2nd oxygen pumping cel, A nitrogen-oxides density measurement means to measure the nitrogen-oxides concentration in measured gas based on the current value which flows in said 2nd oxygen pumping cel, The oxygen density and nitrogen-oxides density measurement equipment characterized by having an oxygen

density measurement means to measure the oxygen density in measured gas from the current value which flows in said 1st oxygen pumping cel.

[Claim 5] The oxygen density and nitrogen-oxides measuring device according to claim 4 characterized by establishing the heater energization control means which controls the energization to said heater so that the temperature of said oxygen density measurement cel detected with a temperature detection means to detect the temperature of said oxygen density measurement cel, and this temperature detection means may turn into predetermined target temperature.

[Claim 6] The oxygen density and nitrogen-oxides density measurement equipment according to claim 5 characterized by establishing the amendment means which carries out temperature compensation of each measurement result by amending the measurement result of said oxygen density and said nitrogen-oxides concentration according to the gap from said target temperature of the temperature of said oxygen density measurement cel detected with said temperature detection means.

[Claim 7] They are the oxygen density and nitrogen-oxides density measurement equipment according to claim 5 or 6 characterized by controlling the energization to said heater so that said temperature detection means may detect the temperature of this cel by detecting the internal resistance of said oxygen density measurement cel and said heater energization control means may serve as a predetermined value corresponding to said target temperature in the internal resistance of the this detected oxygen density measurement cel.

[Claim 8] In said NOx sensor, with said 1st test chamber of said oxygen density measurement cel, while being blockaded, the porous electrode of the opposite side A part of oxygen in this lock out space is formed outside possible [exsorption] through the exsorption resistance section. Said pump current control means A minute current is passed in the direction which pumps out the oxygen in said 1st test chamber in said oxygen density measurement cel in said lock out space. The amount of currents which flows in said 1st oxygen pumping cel so that the electromotive force produced in this oxygen density measurement cel may serve as constant value, operating this lock out space as an internal oxygen reference standard is controlled. Said temperature detection means intercepts periodically connection between said pump current control means and said oxygen density measurement cel. At the time of this cutoff, the bigger current for internal resistance detection than said minute current to hard flow with said minute current to said oxygen density measurement cel A sink, The oxygen density and nitrogen-oxides density measurement equipment according to claim 7 characterized by detecting the internal resistance of said oxygen density measurement cel from the electrical potential difference then produced in inter-electrode [of said oxygen density measurement cel].

[Claim 9] For this the current for internal resistance detection after passing said current for internal resistance detection in said oxygen density measurement cel and detecting internal resistance, said temperature detection means is the oxygen density and nitrogen-oxides density measurement equipment according to claim 8 characterized by passing a current to hard flow.

[Claim 10] In said NOx sensor said 1st oxygen pumping cel, an oxygen density measurement cel, and the 2nd oxygen pumping cel It is formed in the solid electrolyte layer of the shape of sheet metal mutually different, respectively. Said 1st test chamber and 2nd test chamber It is constituted by carrying out the solid electrolyte layer which formed said 1st and 2nd oxygen pumping cel for this each solid electrolyte layer outside, and carrying out a laminating through a predetermined gap. Said heater By becoming a substrate from two heater substrates of the shape of sheet metal of having formed heater wiring, and arranging each heater substrate through a predetermined gap, respectively on direction both sides of a laminating of each solid electrolyte layer in said NOx sensor It is constituted possible [heating of said NOx sensor]. Moreover, said 1st diffusion layer claim 4 characterized by coming to form in an opposite location with the center section of heater wiring formed in said heater substrate of the solid electrolyte layer in which said 1st oxygen pumping cel was formed - claim 9 -- either -- the oxygen density and nitrogen-oxides density measurement equipment of a publication.

[Claim 11] The oxygen density and nitrogen-oxides density measurement equipment according to claim 10 characterized by forming said 2nd diffusion limitation layer so that it may lap with said a part of 1st diffusion limitation layer [at least] when said NOx sensor is projected from [of each of said solid electrolyte layer] a laminating, and coming to arrange said oxygen density measurement

cel near [the 2nd diffusion limitation layer] this.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the oxygen density, the nitrogen-oxides density measurement approach, and equipment which measure an oxygen density and nitrogen-oxides concentration using the NOx sensor constituted in order to detect the concentration of the nitrogen oxides which are the harmful nature discharged from various burning appliances, such as an internal combustion engine.
[0002]
[Description of the Prior Art] From the former, they are European Patent application public presentation specification 0678740A1 and SAE as nitrogen-oxides density measurement equipment. paper No.960334 P137-142 As indicated by the 1996th grade The 1st test chamber opened for free passage through the 1st diffusion limitation layer at the measured gas side, and the 2nd test chamber opened for free passage by this 1st test chamber through the 2nd diffusion limitation layer It forms in the solid electrolyte layer of oxygen ion conductivity. To the 1st test chamber The 1st oxygen pumping cel and an oxygen density measurement cel are formed by pinching a solid electrolyte layer with a porous electrode. Further to the 2nd test chamber What detected the concentration of the nitrogen oxides (NOx) under an internal combustion engine's etc. exhaust air is known using the NOx sensor in which the 2nd oxygen pumping cel was formed, by similarly pinching a solid electrolyte layer with a porous electrode.
[0003] In this kind of nitrogen-oxides density measurement equipment, controlling the oxygen density of the 1st measurement interior of a room to fixed concentration by passing a current in the 1st oxygen pumping cel so that the output voltage from an oxygen density measurement cel serves as constant value set up beforehand, a fixed electrical potential difference is impressed to the 2nd oxygen pumping cel, and oxygen is pumped out of the 2nd test chamber. And the NOx concentration in measured gas is detected from the current value which flows in this 2nd oxygen pumping cel.
[0004] That is, although other gas constituents, such as oxygen, a carbon monoxide, and a carbon dioxide, exist during the exhaust air from the internal combustion engine which is measured gas in addition to NOx By the 2nd test-chamber side into which the measured gas which oxygen controlled the 1st measurement interior of a room by the 1st oxygen pumping cel to very little hypoxia concentration, and was further controlled by the hypoxia concentration flows with the above-mentioned nitrogen-oxides density measurement equipment By impressing a fixed electrical potential difference in the direction which pumps out the oxygen of the 2nd measurement interior of a room in the 2nd oxygen pumping cel By the catalyst function of the porous electrode which constitutes the 2nd oxygen pumping cel By making NOx in measured gas decompose into nitrogen and oxygen, sampling oxygen from the 2nd test chamber, and detecting the pump current which flows in the 2nd oxygen pumping cel then It enables it to detect the NOx concentration in measured gas, without being influenced by other gas constituents in measured gas.
[0005] Moreover, in this kind of nitrogen-oxides measuring device, since it is necessary to heat a sensor to predetermined activity temperature (for example, 800 degrees C or more), and to activate each cel in order to detect NOx concentration correctly by the above-mentioned detection approach, the heater for heating a sensor is formed separately.
[0006]

[Problem(s) to be Solved by the Invention] By the way, in the internal combustion engine (the so-called lean burn engine) with which it is operated with a thin air-fuel ratio (Lean air-fuel ratio) with many amounts of the air over a fuel, and the NOx component under exhaust air increases, the above-mentioned nitrogen-oxides density measurement equipment is used for supervising the condition of the NOx catalyst which returns NOx, in order to control discharge of NOx.
[0007] In that is, the place whose leak of the NOx detected the leak of NOx from an NOx catalyst and has increased by equipping the downstream of the NOx catalyst an internal combustion engine's flueway with an NOx sensor, and measuring NOx concentration the fuel supplied to an internal combustion engine -- it is used for control of controlling the discharge of NOx, by controlling the air-fuel ratio of gaseous mixture to a rich air-fuel ratio with many fuels temporarily, making a unburnt gas discharge from an internal combustion engine, and making this unburnt gas and NOx accumulated in the NOx catalyst react.
[0008] and the fuel supplied to the internal combustion engine with the above-mentioned nitrogen-oxides density measurement equipment in order to have realized such NOx control -- since the air-fuel ratio of gaseous mixture cannot be measured, it is necessary to prepare an internal combustion engine separately the air-fuel ratio measuring device which measures an air-fuel ratio from the oxygen density under exhaust air
[0009] That is, when performing the above NOx control, it is necessary to perform collectively Air Fuel Ratio Control currently generally performed in the internal combustion engine, and, for that, an NOx sensor and an oxygen density sensor (the so-called air-fuel ratio sensor) must be formed in an internal combustion engine's exhaust air system, respectively.
[0010] Then, without using two sensors of an NOx sensor and an air-fuel ratio sensor in this way, it is only an NOx sensor, this invention offers the oxygen density, the nitrogen-oxides density measurement approach, and equipment which can measure NOx concentration and an oxygen density, and in realizing the above NOx control, it aims at simplifying the configuration of the detection system of NOx concentration and an oxygen density (air-fuel ratio).
[0011]
[Means for Solving the Problem] Invention according to claim 1 made in order to attain this purpose The 1st test chamber which has the 1st oxygen pumping cel and oxygen density measurement cel of oxygen ion conductivity which come to insert a solid electrolyte layer with a porous electrode, and was opened for free passage through the 1st diffusion limitation layer at the measured gas side, While having the 2nd oxygen pumping cel which comes to insert the solid electrolyte layer of oxygen ion conductivity with a porous electrode and having said 1st test chamber and the 2nd test chamber opened for free passage through the 2nd diffusion limitation layer The NOx sensor equipped with the heater which heats said each cel to predetermined activity temperature is used. Are the measuring method which measures the oxygen density and nitrogen-oxides concentration in measured gas, and a current is passed in said 1st oxygen pumping cel so that the output voltage of said oxygen density measurement cel may serve as constant value. By impressing a fixed electrical potential difference in the direction which pumps oxygen out of said 2nd test chamber in said 2nd oxygen pumping cel, while controlling uniformly the oxygen density of said 1st measurement interior of a room It is characterized by measuring the nitrogen-oxides concentration in measured gas from the current value which flows in said 2nd oxygen pumping cel, and measuring the oxygen density in measured gas from the current value which flows in said 1st oxygen pumping cel.
[0012] And in a measuring method according to claim 1, invention according to claim 2 is characterized by controlling the energization to said heater so that the temperature of the oxygen density measurement cel in said NOx sensor may turn into predetermined target temperature. Moreover, invention according to claim 3 is characterized by carrying out temperature compensation of each measurement result in a measuring method according to claim 2 according to the gap from said target temperature of the temperature of said oxygen density measurement cel by amending the measurement result of said oxygen density and said nitrogen-oxides concentration.
[0013] On the other hand, invention according to claim 4 uses an NOx sensor according to claim 1 and the same NOx sensor. Are the measuring device which measures the oxygen density and nitrogen-oxides concentration in measured gas, and a current is passed in said 1st oxygen pumping cel so that the output voltage of said oxygen density measurement cel may serve as constant value.

The pump current control means which controls uniformly the oxygen density of said 1st measurement interior of a room, A constant-voltage impression means to impress a fixed electrical potential difference in the direction which pumps oxygen out of said 2nd test chamber in said 2nd oxygen pumping cel, It is characterized by having a nitrogen-oxides density measurement means to measure the nitrogen-oxides concentration in measured gas based on the current value which flows in said 2nd oxygen pumping cel, and an oxygen density measurement means to measure the oxygen density in measured gas from the current value which flows in said 1st oxygen pumping cel.

[0014] And in this measuring device according to claim 4, invention according to claim 5 is characterized by establishing the heater energization control means which controls the energization to said heater so that the temperature of said oxygen density measurement cel detected with a temperature detection means to detect the temperature of said oxygen density measurement cel, and this temperature detection means may turn into predetermined target temperature.

[0015] Moreover, invention according to claim 6 is characterized by establishing the amendment means which carries out temperature compensation of each measurement result by amending the measurement result of said oxygen density and said nitrogen-oxides concentration according to the gap from said target temperature of the temperature of said oxygen density measurement cel detected with said temperature detection means in a measuring device according to claim 5.

[0016] Next, invention according to claim 7 is set again to an oxygen density and nitrogen-oxides density measurement equipment according to claim 5 or 6. Said temperature detection means By detecting the internal resistance of said oxygen density measurement cel, it is characterized by controlling the energization to said heater so that the temperature of this cel may be detected and said heater energization control means may serve as a predetermined value corresponding to said target temperature in the internal resistance of the this detected oxygen density measurement cel.

[0017] Moreover, in an oxygen density and nitrogen-oxides density measurement equipment according to claim 7, in said NOx sensor, with said 1st test chamber of said oxygen density measurement cel, while being blockaded, invention according to claim 8 the porous electrode of the opposite side A part of oxygen in this lock out space is formed outside possible [exsorption] through the exsorption resistance section. Said pump current control means A minute current is passed in the direction which pumps out the oxygen in said 1st test chamber in said oxygen density measurement cel in said lock out space. The amount of currents which flows in said 1st oxygen pumping cel so that the electromotive force produced in this oxygen density measurement cel may serve as constant value, operating this lock out space as an internal oxygen reference standard is controlled. Said temperature detection means intercepts periodically connection between said pump current control means and said oxygen density measurement cel. At the time of this cutoff, it is characterized by detecting the internal resistance of said oxygen density measurement cel from the electrical potential difference which produces the bigger current for internal resistance detection than said minute current a sink and then with said minute current in said oxygen density measurement cel inter-electrode [of said oxygen density measurement cel] at hard flow.

[0018] Moreover, invention according to claim 9 is characterized by passing a current to hard flow with this current for internal resistance detection, after said temperature detection means passes said current for internal resistance detection in said oxygen density measurement cel and detects internal resistance in an oxygen density and nitrogen-oxides density measurement equipment according to claim 8.

[0019] It sets 9 either to the oxygen density and nitrogen-oxides density measurement equipment of a publication. on the other hand -- invention according to claim 10 -- claim 4 - a claim -- In said NOx sensor said 1st oxygen pumping cel, an oxygen density measurement cel, and the 2nd oxygen pumping cel It is formed in the solid electrolyte layer of the shape of sheet metal mutually different, respectively. Said 1st test chamber and 2nd test chamber It is constituted by carrying out the solid electrolyte layer which formed said 1st and 2nd oxygen pumping cel for this each solid electrolyte layer outside, and carrying out a laminating through a predetermined gap. Said heater By becoming a substrate from two heater substrates of the shape of sheet metal of having formed heater wiring, and arranging each heater substrate through a predetermined gap, respectively on direction both sides of a laminating of each solid electrolyte layer in said NOx sensor It is constituted possible [heating of said NOx sensor], and is characterized by moreover coming to form said 1st diffusion layer in an

opposite location with the center section of heater wiring formed in said heater substrate of the solid electrolyte layer in which said 1st oxygen pumping cel was formed.

[0020] Moreover, in an oxygen density and nitrogen-oxides density measurement equipment according to claim 10, when said NOx sensor is projected from [of each of said solid electrolyte layer] a laminating, invention according to claim 11 forms said 2nd diffusion limitation layer so that it may lap with said a part of 1st diffusion limitation layer [at least], and it is characterized by coming to arrange said oxygen density measurement cel near [the 2nd diffusion limitation layer] this.

[0021]

[Embodiment of the Invention] While a current is passed in the 1st oxygen pumping cel so that the output voltage of the oxygen density measurement cel in an NOx sensor may serve as constant value, and controlling uniformly the oxygen density of the 1st measurement interior of a room by the measuring method according to claim 1, a fixed electrical potential difference is impressed in the direction which pumps oxygen out of the 2nd test chamber in the 2nd oxygen pumping cel. That is, by this invention approach, an NOx sensor is driven by the same driving direction as the case where NOx concentration is measured using an NOx sensor. And it not only measures the nitrogen-oxides concentration in measured gas (NOx concentration) from the current value which flows in the 2nd oxygen pumping cel at this time, but it measures the oxygen density in measured gas from the current value which flows in the 1st oxygen pumping cel.

[0022] The pump current control which this controls the current which flows in the 1st pumping cel, and controls the oxygen density of the 1st test chamber uniformly Are the same as the actuation when measuring the oxygen density in measured gas using all the field air-fuel ratio sensors that prepared the pumping cel and the oxygen density measurement cel in the test chamber to which diffusion of measured gas was restricted. It is because the pump current which flows in the 1st pumping cel is proportional to the oxygen density in measured gas and an oxygen density can be measured from the current value.

[0023] And in order to realize NOx control of an internal combustion engine mentioned above in order to measure the oxygen density and NOx concentration in measured gas only using an NOx sensor in this way according to this invention, it is not necessary to form two sensors of an NOx sensor and an air-fuel ratio sensor in an internal combustion engine's exhaust air system, the configuration of the control unit can be simplified, and a cost cut can be aimed at.

[0024] Moreover, in order to measure an oxygen density and NOx concentration using one NOx sensor according to this invention, each [these] measurement result will have very high functionality compared with the case where an oxygen density and NOx concentration are measured using a different sensor (that is, an oxygen sensor and an NOx sensor). Therefore, if the oxygen density and NOx concentration which were measured by this invention approach are used, degradation of the NOx catalyst prepared in an internal combustion engine's exhaust pipe can be judged with high precision.

[0025] That is, what is necessary is to detect how many NOx have leaked out regularly, for that to compare the leak and the control air-fuel ratio at the time of NOx, and just to judge whether the leak of NOx to a control air-fuel ratio is in predetermined tolerance, in order to get to know degradation of an NOx catalyst.

[0026] When the air-fuel ratio of gaseous mixture is small, there are few leaks of NOx. that is, the fuel supplied in the internal combustion engine -- When an air-fuel ratio is large, since the leak of NOx increases, it sets up beforehand the allowed value of an NOx leak to an air-fuel ratio. Conversely, at the time of operation of an internal combustion engine Measure the oxygen density and NOx concentration under exhaust air to coincidence, and read the allowed value of the NOx leak corresponding to the measured oxygen density (if it puts in another way air-fuel ratio), and it judges whether the measured NOx concentration is below the allowed value. If degradation of an NOx catalyst is judged when NOx concentration is over the allowed value, degradation of an NOx catalyst can be judged from the oxygen density under exhaust air, and NOx concentration.

[0027] And if you are trying to use a sensor which is different in measurement of an oxygen density, and measurement of NOx concentration when performing the degradation judging of such an NOx catalyst, it is possible that an error arises in the detection property of NOx concentration over an air-

fuel ratio, and the judgment precision of degradation of an NOx catalyst falls according to the difference of dispersion in the property for every sensor, or extent of degradation etc.
[0028] However, even if dispersion in a property is in the NOx sensor itself [each], there is no difference of dispersion in the air-fuel ratio by one NOx sensor and the detection precision of NOx. And according to this invention, since the oxygen density and NOx concentration in measured gas are measured using one NOx sensor, an error cannot arise in the detection property of NOx concentration over an air-fuel ratio, and degradation of an NOx catalyst can be judged with high precision from the measurement result.
[0029] Next, the energization to the heater formed in the NOx sensor is controlled by the measuring method according to claim 2 so that the temperature of the oxygen density measurement cel in an NOx sensor turns into predetermined target temperature. This is because it is necessary to hold the temperature of the oxygen density measurement cel which measures the oxygen density to constant temperature, in order to be unable to measure oxygen density or NOx concentration correctly, either but to control the oxygen density of the 1st test chamber uniformly, if the oxygen density of the 1st test chamber is uniformly uncontrollable by the energization control (pump current control) to the 1st oxygen pumping cel.
[0030] That is, when the solid electrolyte layer of an oxygen density measurement cel is pinched with the porous electrode of a pair, inter-electrode [the] -- the oxygen tension P1 and P2 by the side of each electrode -- responding -- Nernst's equation (1) EMF=axTxlog (P1/P2) -- (1) -- however a: A proportionality constant and T measure the oxygen density of the 1st measurement interior of a room, when it uses that the electromotive force EMF acquired with absolute temperature arises and the 1st test chamber of an oxygen density measurement room makes the porous electrode side of the opposite side a criteria oxygen density (oxygen tension P1). It follows, for example, if the electromotive force EMF of an oxygen density measurement cel was 200mV and temperature T becomes 800 degrees K when the temperature T of an oxygen density measurement cel is [the oxygen density of the 1st measurement interior of a room] 1000 ppm at 1000 degrees K, electromotive force EMF will be set to 160mV. For this reason, (if it puts in another way, in order to measure an oxygen density and NOx concentration correctly), it is necessary to hold the temperature of an oxygen density measurement cel at constant temperature to control the oxygen density of the 1st test chamber uniformly.
[0031] Although the temperature characteristic stabilized comparatively can be acquired from controlling in all the above-mentioned field air-fuel ratio sensors currently especially used for measurement of an oxygen density conventionally in the condition (oxygen density zero state) that oxygen hardly exists the measurement interior of a room by pump current control By the NOx sensor, if the 1st measurement interior of a room is controlled by pump current control to an oxygen density zero state Since there is a possibility that the NOx component in the measured gas which flowed into the 1st measurement interior of a room may be decomposed, and NOx concentration cannot be measured using the 2nd oxygen pumping cel Usually, the oxygen density of the 1st measurement interior of a room is controlled in the condition (for example, hypoxia concentration which is about 1000 ppm) that oxygen remained for a while, consequently the temperature characteristic falls remarkably compared with all field air-fuel ratio sensors.
[0032] For example, although drawing 10 expresses the relation between the output voltage Vs of the oxygen density measurement cel at the time of measuring the oxygen density of measured gas (oxygen density immobilization) by pump current control which used all the conventional field air-fuel ratio sensors, and the pump current Ip which flows in an oxygen pumping cel So that from this drawing, and the output voltage Vs of an oxygen density measurement cel may be set to 450mV and the oxygen density of the measurement interior of a room may serve as abbreviation zero (it is 10-9atm theoretically extent) When the pump current Ip is controlled, even if it changes the temperature of an oxygen density measurement cel with Ta, Tb, and Tc, although only **IPA changes but the current rate of change per once is about 2%, the pump current Ip When the pump current Ip is controlled to set the output voltage Vs of an oxygen density measurement cel to 150mV, and to become the hypoxia concentration whose oxygen density of the measurement interior of a room is about 1000 ppm If the temperature of an oxygen density measurement cel is changed with Ta, Tb, and Tc, the pump current Ip will change a lot with **IPB, and the current rate of change per once

will become dozens of%.
[0033] Therefore, to control the oxygen density of the 1st measurement interior of a room by pump current control of the 1st oxygen pumping cel in hypoxia concentration of about 1000 ppm in measuring an oxygen density and NOx concentration correctly like this invention using an NOx sensor, it is necessary to control the temperature of an oxygen density measurement cel more to constant temperature at accuracy.
[0034] On the other hand, since according to the measuring method according to claim 2 the energization to a heater is controlled so that the temperature of the oxygen density measurement cel in an NOx sensor turns into predetermined target temperature, an oxygen density measurement cel can be held to fixed target temperature. Therefore, according to the measuring method according to claim 2, it becomes possible to carry out more the NOx control of an internal combustion engine and the degradation judging of an NOx catalyst which could improve and it not only can measure an oxygen density and NOx concentration, but mentioned the accuracy of measurement above to high degree of accuracy using an NOx sensor.
[0035] Next by the measuring method according to claim 3, the measurement result of an oxygen density and nitrogen-oxides concentration is further amended again according to the gap from the target temperature of the temperature of an oxygen density measurement cel. For this reason, in spite of controlling the temperature of an oxygen density measurement cel by energization control to a heater, even if that temperature has changed from target temperature according to this invention approach, temperature compensation of the measurement result of an oxygen density and NOx concentration can be carried out, and an oxygen density and NOx concentration can be measured more to high degree of accuracy.
[0036] When it is got blocked, for example, an internal combustion engine's operational status changes and the temperature of the exhaust air which is measured gas changes suddenly, according to the temperature change of measured gas, the temperature of an NOx sensor changes temporarily and may be unable to control temperature of an oxygen density measurement cel by heater control. However, according to the measuring method according to claim 3, also in such a case, an oxygen density and NOx concentration can be measured correctly.
[0037] Next, a measuring device according to claim 4 is equipment which realizes the measuring method of a publication to above-mentioned claim 1. And while a pump current control means passes a current in the 1st oxygen pumping cel so that the output voltage of an oxygen density measurement cel may serve as constant value, and it controls uniformly the oxygen density of the 1st measurement interior of a room by this equipment first, a constant-voltage impression means impresses a fixed electrical potential difference in the direction which pumps oxygen out of the 2nd test chamber in the 2nd oxygen pumping cel. And a nitrogen-oxides density measurement means measures the nitrogen-oxides concentration in measured gas based on the current value which flows in the 2nd oxygen pumping cel, and an oxygen density measurement means measures the oxygen density in measured gas from the current value which flows in the 1st oxygen pumping cel.
[0038] Therefore, while according to the measuring device according to claim 4 being able to realize the measuring method of a publication to above-mentioned claim 1, being able to simplify the configuration of the control unit which performs NOx control of the internal combustion engine which can measure now the oxygen density and the NOx concentration in measured gas, and mentioned them above using one NOx sensor and being able to aim at the cost cut of the equipment, the degradation judging of the NOx catalyst mentioned above can be performed correctly.
[0039] Next, further, a temperature detection means detects the temperature of an oxygen density measurement cel, and controls the energization to the heater at which the heater energization control means was prepared in the NOx sensor so that the temperature of the detected oxygen density measurement cel might turn into predetermined target temperature by the measuring device according to claim 5 again. That is, a measuring device according to claim 5 is equipment which realizes a measuring method according to claim 2, and it becomes possible it not only can to measure an oxygen density and NOx concentration, but to improve the accuracy of measurement and to perform more NOx control of an internal combustion engine and the degradation judging of an NOx catalyst to accuracy using an NOx sensor.
[0040] Moreover, in a measuring device according to claim 6, an amendment means amends the

measurement result of an oxygen density and said nitrogen-oxides concentration further according to the gap from the target temperature of the temperature of the oxygen density measurement cel detected with the temperature detection means. That is, a measuring device according to claim 6 is equipment which realizes a measuring method according to claim 3, and in spite of controlling the temperature of an oxygen density measurement cel by the heater energization control means to target temperature, even when the temperature has changed from target temperature in response to the effect of temperature changes, such as measured gas, it can carry out temperature compensation of the measurement result of an oxygen density and NOx concentration. For this reason, it becomes possible to measure an oxygen density and NOx concentration to high degree of accuracy more.
[0041] Here, it is also difficult for the structure of an NOx sensor to become complicated in this case, and to detect the temperature of the oxygen density measurement cel itself correctly as a temperature detection means to detect the temperature of an oxygen density measurement cel, for example, although it is also realizable by preparing the component for temperature detection near the oxygen density measurement cel.
[0042] Therefore, it is desirable to control the energization to a heater so that it may become a predetermined value according to claim 7 corresponding to [in / like, constitute a temperature detection means so that the internal resistance of an oxygen density measurement cel may be detected, and / the heater energization control means] target temperature in the internal resistance of the detected oxygen density measurement cel.
[0043] that is, since the internal resistance of an oxygen density measurement cel changes according to the temperature of an oxygen density measurement cel (internal resistance becomes low, so that temperature becomes high), like a publication to claim 7 If the internal resistance of an oxygen density measurement cel is detected, from the detected internal resistance Without preparing the component for temperature detection in an NOx sensor separately, the temperature of an oxygen density measurement cel can be correctly detected now, and temperature control of an NOx sensor (in detail oxygen density measurement cel) can be performed more simply and with high precision.
[0044] Moreover, what is necessary is to impress the constant voltage for internal resistance detection to an oxygen density measurement cel, to constitute so that the amount of currents which flows in an oxygen density measurement cel then may be detected, or just to constitute the constant current for internal resistance detection in an oxygen density measurement cel as a temperature detection means, in this way, for example so that the both-ends electrical potential difference of an oxygen density measurement cel may be detected a sink and then when a temperature detection means detects the internal resistance of an oxygen density measurement cel.
[0045] However, in case the internal resistance of an oxygen density measurement cel is detected in this way, it is necessary to intercept connection between a pump current control means and an oxygen density measurement cel, and to stop energization control of the 1st oxygen pumping cel by the pump current control means temporarily. When it energizes in an oxygen density measurement cel for internal resistance detection, that is, the both-ends electrical potential difference If it becomes the value which does not correspond with the oxygen density of the 1st measurement interior of a room and the control action of a pump current control means is made to continue then Since the oxygen density of the 1st measurement interior of a room will be incorrect-controlled, it is desirable to stop the control action by the pump current control means so that such incorrect control may not arise at the time of internal resistance detection of an oxygen density measurement cel.
[0046] Next, an oxygen density measurement cel is the above-mentioned (1) again. It is necessary to measure the oxygen density of the 1st measurement interior of a room with the electromotive force EMF acquired by the formula, and to make into a fixed criteria oxygen density the oxygen density by the side of the electrode which does not touch the 1st test chamber among the porous electrodes of the pair which constitutes this cel. And although you may make it for that an oxygen density introduce fixed reference gas (for example, atmospheric air) into that electrode side, for example, in order to introduce reference gas from the exterior in this way, the opening for reference gas installation in an NOx sensor will have to be prepared, and the structure of an NOx sensor will become complicated.
[0047] Then, in order to make the porous electrode of the opposite side into a criteria oxygen density with the 1st test chamber of an oxygen density measurement cel While blockading the porous

electrode of the opposite side with the 1st test chamber of an oxygen density measurement cel in an NOx sensor like a publication in claim 8 A part of oxygen in the lock out space forms outside possible [exsorption] through the exsorption resistance section. By the pump current control means side A minute current, operating a sink and its lock out space as an internal oxygen reference standard in the direction which pumps out the oxygen in the 1st test chamber to lock out space to an oxygen density measurement cel What is necessary is just to control the amount of currents which flows in the 1st oxygen pumping cel so that the electromotive force produced in an oxygen density measurement cel may serve as constant value. That is, if constituted in this way, it is not necessary to prepare the opening for reference gas installation in an NOx sensor, and structure of an NOx sensor can be simplified.

[0048] And in order to measure the internal resistance of an oxygen density measurement cel with a temperature detection means in this case Connection between a pump current control means and an oxygen density measurement cel is periodically intercepted for a temperature detection means like a publication to claim 8. It is desirable to detect the internal resistance of an oxygen density measurement cel from the electrical potential difference which produces the bigger current for internal resistance detection than the minute current for internal oxygen reference standard generation a sink and then with a minute current in an oxygen density measurement cel inter-electrode [of an oxygen density measurement cel] at hard flow at the time of the cutoff.

[0049] That is, in order that the oxygen density measurement cel of this invention may carry out self-generation of the internal oxygen reference standard by energization of a minute current, into the lock out space used as the internal oxygen reference standard, oxygen is accumulated enough, when the current for internal resistance detection is passed in a minute current and this direction, the oxygen in lock out space increases too much, and there is a possibility that a crack may go into an NOx sensor by the oxygen with which it was filled.

[0050] Then, in order to detect the internal resistance of an oxygen density measurement cel, he is trying to detect the internal resistance of an oxygen density measurement cel with the sometimes passed [usually] minute current to an oxygen density measurement cel in a measuring device according to claim 8 from the inter-electrode electrical potential difference which produced the current for internal resistance detection a sink and then to hard flow.

[0051] In addition, when a current is passed in an oxygen density measurement cel, although the electrical potential difference (inter-electrode electrical potential difference) which an oxygen density measurement cel generates changes not only with the internal resistance of an oxygen density measurement cel but with the electromotive force generated according to the ratio of the oxygen density by the side of each electrode The oxygen density by the side of each electrode of an oxygen density measurement cel (that is, the oxygen density of the 1st measurement interior of a room and the oxygen density in lock out space) Since it is abbreviation regularity by energization of a minute current, and energization control of the 1st oxygen pumping cel by the pump current control means, respectively, The electromotive force immediately after energization initiation of the current for internal resistance detection is fixed a degree, and according to this invention, the internal resistance of an oxygen density measurement cel can be detected, without being influenced of this electromotive force.

[0052] Moreover, in this way, in order to detect the internal resistance of an oxygen density measurement cel, when the current for internal resistance detection is passed in an oxygen density measurement cel, an oxygen density measurement cel works as a pumping cel, and oxygen moves it to hard flow with the direction of a current according to the amount of energization currents. Consequently, the oxygen density in lock out space falls according to the current for internal resistance detection, and its resistance welding time. In order for the oxygen density in lock out space to be able to detect correctly the oxygen density of the 1st measurement interior of a room in return and an oxygen density measurement cel to a criteria oxygen density by energization of a minute current after internal resistance detection Even if it requires a certain amount of time amount and makes the control action of a pump current control means resume from immediately after internal resistance detection, the oxygen density and NOx concentration in measured gas cannot be measured correctly.

[0053] and what is necessary is just to constitute with the current for internal resistance detection,

after internal resistance detection, so that a current may be passed to hard flow after [according to claim 9] passing the current for internal resistance detection for a temperature detection means in an oxygen density measurement cel and detecting internal resistance like in order to boil short time amount until it can measure an oxygen density and NOx concentration correctly and to carry out it
[0054] That is, at the time of internal resistance detection of an oxygen density measurement cel, if the current for internal resistance detection is passed in an oxygen density measurement cel at alternation, time amount until the oxygen density by the side of each electrode of an oxygen density measurement cel and the condition of a temporary electromotive force fall of an oxygen density measurement cel will return to the stable state before internal resistance detection promptly and can measure an oxygen density and NOx concentration correctly after internal resistance detection can be shortened.
[0055] The temperature of the oxygen density measurement cel which detects the oxygen density of the 1st measurement interior of a room which affects most the accuracy of measurement of an oxygen density and NOx concentration next again among three sorts of cels which constitute the NOx sensor from this invention is detected. Although the energization current to a heater is controlled so that the temperature turns into target temperature, it is also considered that the temperature of the 1st oxygen pumping cel or the 2nd oxygen pumping cel shifts from target temperature greatly depending on the structure of an NOx sensor, and the accuracy of measurement of an oxygen density and NOx concentration cannot be secured.
[0056] Then, in order to make it obtained more by fitness, the effectiveness by the heater energization control means It sets in an NOx sensor like the publication to claim 10. The 1st oxygen pumping cel, an oxygen density measurement cel, and the 2nd oxygen pumping cel It is formed in the solid electrolyte layer of the shape of sheet metal mutually different, respectively. The 1st test chamber and the 2nd test chamber It is constituted by carrying out the solid electrolyte layer which formed the 1st and 2nd oxygen pumping cel for each solid electrolyte layer outside, and carrying out a laminating through a predetermined gap. A heater By becoming a substrate from two heater substrates of the shape of sheet metal of having formed heater wiring, and arranging each heater substrate through a predetermined gap, respectively on direction both sides of a laminating of each solid electrolyte layer in an NOx sensor It is desirable for it to be constituted possible [heating of an NOx sensor] and to form the 1st diffusion layer in an opposite location with the center section of heater wiring formed in the heater substrate of the solid electrolyte layer in which the 1st oxygen pumping cel was formed moreover.
[0057] If an NOx sensor and a heater are formed as mentioned above, that is, the solid electrolyte layer in which the oxygen density measurement cel was formed Since it will be inserted into the solid electrolyte layer in which the 1st oxygen pumping cel and the 2nd oxygen pumping cel were formed and a heater substrate will be arranged further at the direction both sides of a laminating If the temperature of an oxygen density measurement cel is controlled by energization control of a heater to target temperature The 1st oxygen pumping cel and the 2nd oxygen pumping cel can be more certainly controlled to target temperature, and the measured gas which moreover flows into the 1st test chamber from the 1st diffusion layer can also be enough heated now at a heater.
[0058] Consequently, according to the measuring device according to claim 10, while lessening dispersion in the temperature of each cel in an NOx sensor, each cel makes effect of the temperature of measured gas hard to be influenced, and it becomes possible to improve more the accuracy of measurement of an oxygen density and NOx concentration.
[0059] Moreover, in this case, like, it forms so that the 2nd diffusion limitation layer may be lapped with a part of 1st diffusion limitation layer [at least] in it, when [according to claim 11] an NOx sensor is projected from [of each solid electrolyte layer] a laminating. If an oxygen density measurement cel is arranged near [this] the 2nd diffusion limitation layer, the temperature of an NOx sensor and the measured gas of that interior can be certainly controlled by target temperature, and the accuracy of measurement of an oxygen density and NOx concentration can be improved.
[0060]
[Example] One example of this invention is explained with a drawing below. The outline block diagram with which drawing 1 expresses the configuration of the whole oxygen density and nitrogen-oxides density measurement equipment of an example with which this invention was

applied, and drawing 2 are the decomposition perspective views of the NOx sensor 2 used in this measuring device. The 1st oxygen pumping cel from which the measuring device of this example constitutes the NOx sensor 2 and the NOx sensor 2 as shown in drawing 1 (It is hereafter called the 1st pump cel) While performing the energization to 4 and the oxygen density measurement cel (henceforth Vs cel) 6, and a switch of an energization path The drive circuit 40 which detects the current (henceforth the 1st pump current) IP 1 which flows in the 1st pump cel 4, The detector 42 which detects the current (henceforth the 2nd pump current) IP 2 which impresses a constant voltage to the 2nd oxygen pumping cel (henceforth the 2nd pump cel) 8 which constitutes the NOx sensor 2, and flows then, While controlling the heater energization circuit 44 which it energizes [circuit] to the heaters 12 and 14 of the pair prepared in the NOx sensor 2, and makes each cels 4, 6, and 8 heat, and the drive circuit 40 and the heater energization circuit 44 Detecting signals [VIP / VIP and / 2] 1 from the drive circuit 40 and a detector 42 It consists of electronic control circuits (henceforth ECU) 50 which are based and calculate the oxygen density and NOx concentration in measured gas and which consist of a microcomputer.
[0061] As shown in drawing 2 , it sets in the NOx sensor 2. The 1st pump cel 4 Form the rectangle-like porous electrodes 4b and 4c and lead section 4bl of those, and 4cl, and further, a round hole is drilled in the both sides of solid electrolyte layer 4a formed in tabular at solid electrolyte layer 4a, respectively so that a part for the core of porous electrodes 4b and 4c may be penetrated. By putting a porous filler in the round hole, 4d of diffusion limitation layers is formed.
[0062] The Vs cel 6 moreover, on both sides of solid electrolyte layer 4a of the 1st pump cel 4, and isomorphism-like solid electrolyte layer 6a 6d of diffusion limitation layers is formed by forming the porous electrodes 6b and 6c of a circle configuration and lead section 6bl of those, and 6cl, drilling a round hole in solid electrolyte layer 6a further, respectively so that a part for the core of porous electrodes 6b and 6c may be penetrated, and putting a porous filler in the round hole.
[0063] And when the center position on solid electrolyte layer 4a and 6a carries out abbreviation coincidence of the porous electrodes 6b and 6c of this Vs cel 6, and the porous electrodes 4b and 4c of the 1st pump cel 4 and the laminating of the Vs cel 6 and the 1st pump cel 4 is carried out, he is trying for 4d to counter mutually 6d of each diffusion limitation layer. Moreover, the porous electrodes 6b and 6c of the circle configuration formed in the Vs cel 6 are smaller than the porous electrodes 4b and 4c of the shape of a rectangle formed in the 1st pump cel 4. Moreover, in the front rear face of the Vs cel 6, in order to prevent the current leak from lead section 6bl and 6cl lead section 6bl and 6cl -- the wrap from an outside -- the insulator layer which consists of an alumina etc. like forms -- having -- **** -- moreover -- each -- in lead section 6bl and 6cl 6f of exsorption resistance sections which make a part of oxygen poured into the porous electrode 6c side by the below-mentioned energization control leak to the porous electrode 6b side is formed.
[0064] Thus, the laminating of the 1st pump cel 4 and the Vs cel 6 which were formed is carried out through each above-mentioned solid electrolyte layers 4a and 6a and the isomorphism-like solid electrolyte layer 18. And the hole of the shape of a bigger rectangle than porous electrode 4c is drilled in the opposite location with each porous electrodes 4c and 6b of this solid electrolyte layer 18, and this hole functions as the 1st test chamber 20.
[0065] Moreover, the laminating of each above-mentioned solid electrolyte layers 4a and 6a and the isomorphism-like solid electrolyte layer 22 is carried out also to the porous electrode 6c side of the Vs cel 6. And 22d of diffusion limitation layers is formed in this solid electrolyte layer 22 by drilling the round hole of this dimension in 6d of diffusion limitation layers and homotopic of the Vs cel 6, and putting a porous filler in that round hole.
[0066] On the other hand, the 2nd pump cel 8 forms the rectangle-like porous electrodes 8b and 8c and lead section 8bl of those, and 8cl in the both sides of solid electrolyte layer 8a formed in tabular like the 1st pump cel 4, respectively. And the laminating of this 2nd pump cel 8 is carried out to the solid electrolyte layer 22 through the solid electrolyte layer 18 and the solid electrolyte layer 24 completely formed similarly. Consequently, the hole of the shape of a rectangle drilled by the solid electrolyte layer 24 will function as the 2nd test chamber 26.
[0067] And the NOx sensor 2 except heaters 12 and 14 is produced by sintering at predetermined temperature, after carrying out the laminating of each part of the above and unifying. Moreover, predetermined spacing is opened with spacers 28 and 29, and the laminating of the heaters 12 and 14

is carried out to the both sides of the layered product of the 1st pump cel 4 by which a laminating is carried out in this way, the Vs cel 6, and the 2nd pump cel 8, i.e., the outside of the 1st pump cel 4 and the 2nd pump cel 8, respectively.

[0068] These heaters 12 and 14 with each above-mentioned solid electrolyte layers 4a and 6a and -- The isomorphism-like heater substrates 12a and 14a, It consists of the heater wiring 12b and 14b formed in the opposed face side with each above-mentioned cels 4 and 8 of each heater substrates 12a and 14a and lead section 12bl of those, and 14bl. Spacers 28 and 29 With the porous electrodes 4b and 8c of the 1st pump cel 4 and the 2nd pump cel 8, these heater wiring 12b and 14b is arranged at the lead section 12bl [of the heater wiring 12b and 14b], and 14bl side, respectively so that it may counter mutually through a gap.

[0069] The heater substrates 12a and 14a are made of the alumina, and screen-stencil, calcinate and form in the sheet of an alumina what heater wiring mixed the alumina to platinum powder, and was made into the shape of a paste. In addition, an alumina sheet serves as the heater substrates 12a and 14a and spacers 28 and 29 by baking. And it is joined using ceramic system adhesives from both sides of the already calcinated 1st pump cel 4 and the 2nd pump cel 8, and heaters 12 and 14 serve as the perfect NOx sensor 2.

[0070] Here, as each above-mentioned solid electrolyte layers 4a and 6a and a solid electrolyte ingredient which constitutes --, although a zirconia, the solid solution and the zirconia of yttria, and the solid solution of calcia are typical, the solid solution of hafnia, the perovskite mold oxide solid solution, the trivalent metal oxide solid solution, etc. can be used for others. Moreover, it is desirable to use the platinum which has a catalyst function, and a rhodium or its alloy for the porous electrode prepared in the front face of each solid electrolyte layers 4a, 6a, and 8a. And as the formation approach, what mixed a solid electrolyte layer and the powder of the same ingredient to platinum powder, for example is made into the shape of a paste, it screen-stencils on a solid electrolyte layer, and the thick-film formation approach subsequently sintered and the coat formation approach by vacuum evaporationo are learned. Moreover, as for the diffusion limitation layers 4d, 6d, and 22d, it is desirable to use the ceramics which has a thin through tube, and porous ceramics.

[0071] On the other hand, heater wiring 12b and 14b of heaters 12 and 14 is used as the composite material of the ceramics, platinum, or a platinum alloy, and in order to fall resistance and to reduce the electric loss in the lead section, considering as platinum or a platinum alloy is desirable [the lead section 12bl and 14bl]. Moreover, an alumina, a spinel, forsterite, a steatite, a zirconia, etc. can be used for the heater substrates 12a and 14a and spacers 28 and 29.

[0072] Next, as shown in drawing 1 , the porous electrodes 4c and 6b by the side of the 1st test chamber 20 of the 1st pump cel 4 of the NOx sensor 2 and the Vs cel 6 are grounded through the resistor R1, and the porous electrodes 4b and 6c of another side are connected to the drive circuit 40. The resistor R2 by which, as for the drive circuit 40, the constant voltage VCP was impressed to the end, and the other end was connected to porous electrode 6c of the Vs cel 6 through the open/close switch SW1, - the differential amplifier AMP by which porous electrode 6c of the Vs cel 6 was connected to the side input terminal through the open/close switch SW1, reference voltage VCO was impressed to + side input terminal, and the output terminal was connected to porous electrode 4b of the 1st pump cel 4 through the resistor R0 -- since -- it has becoming control-section 40a.

[0073] This control-section 40a operates as follows, when an open/close switch SW1 is in an ON state. First, the oxygen in the 1st test chamber 20 is poured into the porous electrode 6c side of the Vs cel 6 by passing the fixed minute current iCP in the Vs cel 6 through a resistor R2. Since this porous electrode 6c is open for free passage the porous electrode 6b side through 6f of exsorption resistance sections while being blockaded by the solid electrolyte layer 22, the lock out space in porous electrode 6c serves as a fixed oxygen density by energization of the minute current iCP, and it functions as an internal oxygen reference standard.

[0074] Moreover, if the porous electrode 6c side of the Vs cel 6 functions as an internal oxygen reference standard in this way, in the Vs cel 6, the electromotive force according to the ratio of the oxygen density in the 1st test chamber 20 and the oxygen density by the side of an internal oxygen reference standard will occur, and the porous electrode 6c side electrical potential difference Vs will turn into an electrical potential difference according to the oxygen density in the 1st test chamber 20 at it. And since this electrical potential difference is inputted into the differential amplifier AMP,

from the differential amplifier AMP, the electrical potential difference according to the deflection (VCO-input voltage) of reference voltage VCO and its input voltage is outputted, and this output voltage is impressed to porous electrode 4b of the 1st pump cel 4 through a resistor R0.
[0075] Consequently, the 1st pump current IP 1 flows in the 1st pump cel 4, and it is controlled so that the electromotive force generated in the Vs cel 6 according to this 1st pump current IP 1 serves as a fixed electrical potential difference (it becomes fixed concentration like [if it puts in another way / the oxygen density in the 1st test chamber 20]). That is, when it functions as a pump current control means and measured gas has flowed in the 1st test chamber 20 through 4d of diffusion limitation layers, this control-section 40a controls the oxygen density in the 1st test chamber 20 so that the oxygen density in the 1st test chamber 20 turns into fixed concentration.
[0076] In addition, the oxygen density in the 1st test chamber 20 controlled in this way is set up so that energization of the 1st pump current IP 1 may not decompose the NOx component in the measured gas in the 1st test chamber 20 and oxygen may serve as hypoxia concentration (for example, about 1000 ppm) which exists for a while, and the value of 100mV - about 200mV is set to the reference voltage VCO which determines this oxygen density. Moreover, the resistor R0 prepared between the output of the differential amplifier AMP and porous electrode 4b is for detecting the 1st pump current IP 1, and it is the both-ends electrical potential difference VIP 1. It is inputted into ECU50 as a detecting signal of the 1st pump current IP 1.
[0077] In the drive circuit 40, at the above-mentioned control-section 40a Next, in addition, current regulator circuit 40b which is connected to porous electrode 6c of the Vs cel 6 through an open/close switch SW2, and passes constant current to hard flow in the above-mentioned minute current iCP among porous electrode 6b-6c, It connects with porous electrode 6c of the Vs cel 6 through an open/close switch SW3, and has current regulator circuit 40c which passes constant current in the above-mentioned minute current iCP and this direction among porous electrode 6b-6c.
[0078] Each [these] current regulator circuits 40b and 40c are for detecting the internal resistance RVS of the Vs cel 6. And in order to enable it for energization of this constant current to detect the internal resistance RVS of the Vs cel 6 by the ECU50 side, the porous electrode 6c side electrical potential difference Vs is inputted into ECU50. In addition, the constant current which each current regulator circuits 40b and 40c pass is set as the same current value only by the directions of a current differing. And this current value is larger than the minute current iCP supplied to the Vs cel 6 through a resistor R2.
[0079] Moreover, the open/close switches SW1-SW3 formed, respectively between control-section 40a, current regulator circuits 40b and 40c, and porous electrode 6c of the Vs cel 6 are turned on and off by the control signal from ECU50, and perform measurement actuation of an oxygen density and NOx concentration. Usually, only when only an open/close switch SW1 will be in an ON state, control-section 40a operates and it sometimes detects the internal resistance RVS of the Vs cel 6, an open/close switch SW1 will be in an OFF state, and open/close switches SW2 and SW3 are controlled by the ON state in order.
[0080] On the other hand, between porous electrode 8b of the 2nd pump cel 8 of the NOx sensor 2, and 8c, a constant voltage VP 2 is impressed through the resistor R3 as a constant-voltage impression means to constitute the above-mentioned detector 42. In the 2nd pump cel 8, a current flows from porous electrode 8c to the 8b side, and as for the impression direction of this constant voltage VP 2, the porous electrode 8c side is set up so that the positive-electrode and porous electrode 8b side may serve as a negative electrode, so that the oxygen in the 2nd test chamber 26 may be pumped out outside. Moreover, this constant voltage VP 2 decomposes the NOx component in the measured gas of the 2nd measurement interior of a room which flows through the diffusion limitation layers 6d and 22d from the 1st test chamber 20, and is set to the electrical potential difference which can pump out that oxygen component, for example, 450mV.
[0081] In addition, it is an electrical potential difference VIP 2 about the 2nd pump current IP 2 to which a resistor R3 flows in the 2nd pump cel 8 by impression of this constant voltage VP 2. It is for changing and inputting into ECU50 as a detecting signal of the 2nd pump current IP 2. Thus, it sets to the oxygen density and nitrogen-oxides density measurement equipment of constituted this example. If the open/close switch SW1 in the drive circuit 40 is turned on and open/close switches SW2 and SW3 are turned off The oxygen density in the 1st test chamber 20 into which measured gas

flows through 4d (the 1st diffusion limitation layer) of diffusion limitation layers is controlled by actuation of control-section 40a by the fixed oxygen density. Since the measured gas in the 1st test chamber 20 controlled by the fixed oxygen density flows into the 2nd test chamber 26 through the diffusion limitation layers (the 2nd diffusion limitation layer) 6d and 22d, The 1st pump current IP 1 which flows in the 1st pump cel 4 changes according to the oxygen density in measured gas. The 2nd pump current IP 2 which flows in the 2nd pump cel 8 comes to change according to the NOx concentration in measured gas. Detecting signals VIP1 and VIP2 which express each [these] currents IP1 and IP2 with the ECU50 side The oxygen density and NOx concentration in measured gas can be measured by reading and performing predetermined data processing.
[0082] By the way, it is necessary to control uniformly the temperature of each above-mentioned cels 4, 6, and 8, and the temperature of the Vs cel 6 which detects the oxygen density in the 1st test chamber 20 especially, and for that, in order to secure the accuracy of measurement of each [these] concentration, it is necessary to control the amount of energization currents from the heater energization circuit 44 to each heaters 12 and 14 so that the temperature of the Vs cel 6 turns into target temperature. So, in ECU50, by switching the on-off condition of the above-mentioned open/close switches SW1-SW3, the temperature of the Vs cel 6 is detected from that internal resistance RVS, and the amount of energization from the heater energization circuit 44 to heaters 12 and 14 is controlled by this example so that this detected internal resistance RVS serves as constant value (that is, the temperature of the Vs cel 6 target temperature).
[0083] Hereafter, the control processing performed in ECU50 for such temperature control and density measurement is explained along with the flow chart shown in drawing 3 and drawing 4 . In addition, in order that drawing 3 may measure an oxygen density and NOx concentration, the oxygen density and NOx density measurement processing repeatedly performed in ECU50 are expressed, and drawing 4 expresses the internal resistance detection processing performed in ECU50 as interrupt processing of every fixed time amount T0 (for example, 1sec.), in order to detect the internal resistance RVS of the Vs cel 6 and to control the energization to heaters 12 and 14.
[0084] As shown in drawing 3 , in an oxygen density and NOx density measurement processing, activation judging processing in which it waits to activate the NOx sensor 2 is first performed after starting of the measuring device concerned S100 (S expresses a step) by judging whether the NOx sensor 2 was activated by energization to heaters 12 and 14.
[0085] This activation judging processing is performed by judging whether the internal resistance RVS of the Vs cel 6 detected by the below-mentioned internal resistance detection processing became below the activation decision value set up beforehand. That is, as shown in drawing 5 , since the internal resistance RVS of the Vs cel 6 decreases as a chip temperature rises and the Vs cel 6 is activated, after energization starting to heaters 12 and 14, it judges whether the chip temperature reached predetermined activation temperature by S100 by judging whether the internal resistance RVS of the Vs cel 6 became below an activation decision value.
[0086] Moreover, although the open/close switch SW1 in the drive circuit 40 is controlled by the ON state and open/close switches SW2 and SW3 are controlled by initialization processing which is not illustrated by the OFF state immediately after starting of the measuring device concerned, actuation of the differential amplifier AMP in the drive circuit 40 stops until the NOx sensor 2 goes up even near the activation temperature by activation judging processing of the above S100. This is because the internal resistance RVS of the Vs cel 6 is large, so an overcurrent will flow in the 1st pump cel 4 if the porous electrode 6c side electrical potential difference Vs inputted into the differential amplifier AMP becomes high too much and the differential amplifier AMP is operated in the condition that the NOx sensor 2 is not being activated.
[0087] Next, detecting signal VIP 2 which will shift to S110 and will be inputted from the resistor R3 of a detector 42 if it is judged that the NOx sensor 2 was activated in S100 By reading, processing as a nitrogen-oxides density measurement means to detect the 2nd pump current IP 2 is performed. Moreover, detecting signal VIP 1 inputted from the resistor R0 of the drive circuit 40 in S120 continuing By reading, processing as an oxygen density measurement means to detect the 1st pump current IP 1 is performed.
[0088] And in S130 continuing, the amount of criteria amendments to the 2nd pump current IP 2 is computed based on the detected 1st pump current IP 1. That is, in this example, since the oxygen

density in the 1st test chamber 20 is controlled by pump current control by the above-mentioned drive circuit 40 to hypoxia concentration not to decompose the NOx component in the measured gas in the 1st test chamber 20, not only NOx in measured gas but oxygen flows into the 2nd test chamber 26. Therefore, although the 2nd pump current IP 2 changes corresponding to the NOx concentration in measured gas, the effect of the oxygen density in measured gas also receives it. Although an example of the measurement result of the 1st pump current IP 1 at the time of drawing 6 making measured gas the gas for a trial which does not contain NOx, and operating the equipment concerned, and the 2nd pump current IP 2 is expressed The 1st pump current IP 1 changes with a fixed inclination corresponding to the oxygen density in measured gas, and the 2nd pump current IP 2 changes in response to the effect of the oxygen density in measured gas so that clearly also from this drawing.

[0089] Then, in this example, in order to make the 2nd pump current IP 2 correspond only to the NOx concentration in measured gas The value of the 2nd pump current IP 2 corresponding to the oxygen density obtained when the measured gas which does not contain NOx as mentioned above is measured Memorize beforehand to storages, such as ROM, as an offset value for 2nd pump current IP2 amendment, and the oxygen density in measured gas is detected from the 1st pump current IP 1. He reads the offset value corresponding to this oxygen density out of the offset value data memorized beforehand, and is trying to set it up as the above-mentioned amount of criteria amendments.

[0090] In addition, in case this amount of criteria amendments is actually computed, the map which memorized the offset value (that is, the amount of criteria amendments) corresponding to the 1st pump current IP 1 is used, and the amount of direct criteria amendments is calculated from the 1st pump current IP 1 by searching this map by making the 1st pump current IP 1 into a parameter.

[0091] In this way, if the amount of criteria amendments is computed, it will shift to S140 shortly and the internal resistance RVS of the Vs cel 6 obtained by the below-mentioned internal resistance detection processing will be read. And in S150 continuing, the amount of temperature compensation to the 2nd pump current IP 2 is computed based on this read internal resistance RVS.

[0092] That is, although the energization to heaters 12 and 14 is controlled by this example so that the internal resistance RVS of the Vs cel 6 is detected and the internal resistance RVS serves as a predetermined value in the below-mentioned internal resistance detection processing (the temperature of the NOx sensor 2 will turn into predetermined target temperature if it puts in another way like) When the temperature of measured gas changes suddenly, temperature control cannot be made to follow the temperature change of measured gas, but the temperature of the NOx sensor 2 may change with the temperature changes of measured gas.

[0093] For example, that the NOx concentration under an internal combustion engine's exhaust air should be measured using the measuring device of this example, drawing 7 attaches the NOx sensor 2 in an internal combustion engine's exhaust pipe, and expresses an example of the measurement result of having measured the temperature change of the NOx sensor 2 at the time of operating the equipment concerned. So that clearly from this drawing in the measuring device of this example If an exhaust-gas temperature falls temporarily or an exhaust-gas temperature rises temporarily with reduction of an inhalation air content with increase of an inhalation air content at the time of moderation of an internal combustion engine at the time of acceleration of an internal combustion engine in spite of performing the below-mentioned temperature control In response to the effect of the temperature change, both the 1st pump current IP 1 and the 2nd pump current IP 2 change, and the NOx sensor 2 will require the time amount also for about 1 minute, by the time especially the 2nd pump current IP 2 returns to a stable state. In addition, this is for returning the oxygen density to target concentration after that to take time amount, once the oxygen density in the 1st test chamber 20 shifts from target concentration, when the 1st pump current IP 2 is influenced of an exhaust-gas temperature.

[0094] Then, even if the temperature of measured gas changes suddenly, in order to enable it to measure NOx concentration correctly from the 2nd pump current IP 2, he searches for the temperature of the Vs cel 6 from the internal resistance RVS of the Vs cel 6, for example, is trying to ask drawing 8 for the amount of temperature compensation to the 2nd pump current IP 2 in this example using the map for the amount calculation of **** temperature compensation.

[0095] In addition, although the map shown in drawing 8 is set up so that the amount of temperature compensation may be calculated from the chip temperature of the Vs cel 6, it can calculate the amount of direct temperature compensation from internal resistance RVS, without converting internal resistance RVS into temperature, if the map for the amount calculation of temperature compensation which makes a parameter internal resistance RVS of the Vs cel 6 is set up beforehand. Moreover, for example, the map which makes a parameter deflection of a chip temperature and target temperature (target temperature is 850 degrees C in drawing 8) is set up beforehand. You may make it calculate the amount of temperature compensation from the gap (deflection) from the target temperature of a chip temperature. The map which makes a parameter deflection of internal resistance RVS and the target resistance corresponding to target temperature is set up beforehand, and you may make it calculate the amount of temperature compensation from the gap (deflection) from the target resistance of internal resistance RVS.
[0096] Next, if the amount of temperature compensation is computed in S150, it will shift to S160 and the 2nd pump current IP 2 will be amended by adding the amount of criteria amendments, and the amount of temperature compensation to the 2nd pump current IP 2 detected by S110. And in S170 continuing, the 2nd pump current IP 2 after this amendment is outputted to external devices (engine control system etc.) as a measurement result of NOx concentration.
[0097] Next by S180, the amount of temperature compensation to the 1st pump current IP 1 is computed again based on the internal resistance RVS read by S140. And using this computed amount of temperature compensation, the 1st pump current IP 1 detected by S120 is amended, and in S200 continuing, the 1st pump current IP 1 after this amendment is outputted to an external device as a measurement result of an oxygen density, and it shifts to S110 again S190 continuing.
[0098] In addition, processing of S180 and S190 is processing for making the 1st pump current IP 1 correspond to the oxygen density in measured gas, without being influenced by the temperature change of the NOx sensor 2, and computes the amount of temperature compensation to the 1st pump current IP 1 like the above S150 in S180 using the map set up beforehand.
[0099] And in this example, processing of S150, S160, S180, and S190 which are performed in order to amend the 2nd pump current IP 2 corresponding to NOx concentration and the 1st pump current IP 1 corresponding to an oxygen density according to the temperature of the Vs cel 6, respectively is equivalent to the amendment means of this invention.
[0100] By this example, it sets here to above-mentioned oxygen density and NOx density measurement processing. The amount of criteria amendments for amending the 2nd pump current IP 2 according to the oxygen density in measured gas based on the 1st pump current IP 1, Although explained as what calculates the amount of temperature compensation for amending the 2nd pump current IP 2 according to the temperature of the Vs cel 6 separately, and amends the 2nd pump current IP 2 For example, by setting up the map for the amount calculation of criteria amendments, and switching the map used for calculation of the amount of criteria amendments according to the temperature of the Vs cel 6 for every temperature of the Vs cel 6 You may make it calculate the amount of amendments for amending the 2nd pump current IP 2 according to the oxygen density in measured gas, and the temperature of the Vs cel 6. The two-dimensional map for the amount calculation of amendments which makes a parameter the 1st pump current IP 1 and temperature (or internal resistance RVS) of the Vs cel 6 is set up beforehand, and you may make it calculate the amount of amendments to the 2nd pump current IP 2 using this map.
[0101] Next, the internal resistance detection processing shown in drawing 4 is explained. In addition, not only the function as a temperature detection means to only detect the internal resistance RVS of the Vs cel 6 but the function as a heater energization control means which controls the amount of energization currents to heaters 12 and 14 through the heater energization circuit 44 from that detection result has this internal resistance detection processing.
[0102] If this processing is started as shown in drawing 4 , in S210, the porous electrode 6c side electrical potential difference Vs of the Vs cel 6 will be read, and this will be set up as a basic detection electrical potential difference VS 1 of the Vs cel 6. And in S220 continuing, constant current is passed in the minute current iCP to the Vs cel 6 to hard flow (that is, direction which pours oxygen into the 1st test-chamber 20 side from the lock out space side which had become an internal oxygen reference standard until now) by turning off the open/close switch SW1 made into the ON

state for density measurement, and turning on the open/close switch SW2 connected to current regulator circuit 40b.
[0103] Moreover, in S230 continuing, after starting of the detection processing concerned, if waiting and predetermined time T1 pass that predetermined time T1 passes by judging whether predetermined time T1 (for example, 60microsec.) passed, the porous electrode 6c side electrical potential difference Vs of the Vs cel 6 will be read, and this will be set up S240 as a resistance detection electrical potential difference VS 2 of the Vs cel 6.
[0104] In this way, by shifting to S250 and judging whether predetermined time T2 (for example, 100microsec.) passed after starting of the detection processing concerned, if the resistance detection electrical potential difference VS 2 is set up When waiting and predetermined time T2 pass, that predetermined time T2 passes in S260 By turning off the open/close switch SW2 used as the ON state between fixed time amount T2 after starting of the detection processing concerned, and turning on the open/close switch SW3 connected to current regulator circuit 40c Constant current is passed in the Vs cel 6 in the minute current iCP and this direction (that is, direction which pours the oxygen in the 1st test chamber 20 into a lock out space side).
[0105] Thus, if waiting and predetermined time T3 pass that predetermined time T3 passes by shifting to S270 and judging whether predetermined time T3 (for example, 200microsec.) passed after starting of the detection processing concerned this time if an open/close switch SW3 is turned on, an open/close switch SW3 is turned off in S280. Consequently, the open/close switches SW1-SW3 in the drive circuit 40 will be in an OFF state altogether.
[0106] And in S290 continuing, deflection **Vs (=VS1-VS2) of the basic detection electrical potential difference VS 1 set up immediately after starting of the detection processing concerned and the resistance detection electrical potential difference VS 2 set up after predetermined time T1 progress is calculated, and it shifts to S310 which computes the internal resistance RVS of this Vs cel 6 from deflection **Vs, and continues in S300. In addition, the calculation technique of the internal resistance RVS in this example is explained in detail later.
[0107] The deflection of the internal resistance RVS of the Vs cel 6 and desired value which carried out [above-mentioned] calculation in S310, Or it is based on the deflection of the temperature of the Vs cel 6 and target temperature which are acquired from internal resistance RVS. The control signal (heater control signal) the increase of the amount of energization currents to heaters 12 and 14 and for carrying out a decrease is outputted to the heater energization circuit 44, and processing as a heater energization control means which controls the amount of currents supplied to heaters 12 and 14 from the heater energization circuit 44 is performed.
[0108] in addition, in this heater energization control, when energization and un-energizing to heaters 12 and 14 are constituted from a switching circuit which can be switched to a high speed, the heater energization circuit 44 That what is necessary is just to control the duty ratio of the driving pulse which switches its energization and un-energizing Moreover, what is necessary is just to make it fluctuate an electrical potential difference based on the heater control signal from ECU50, when the output voltage to heaters 12 and 14 is constituted for the heater energization circuit 44 from a controllable armature-voltage control circuit.
[0109] When a heater control signal is outputted in this way, and shortly By shifting to S320 and judging whether predetermined time T four (for example, 500microsec.) passed after starting of the detection processing concerned When waiting and predetermined time T four pass that predetermined time T four passes, measurement actuation of an oxygen density and NOx concentration is made to resume by turning on the open/close switch SW1 used as the OFF state between fixed time amount T four after starting of the detection processing concerned, and ending the detection processing concerned in S330.
[0110] In internal resistance detection processing in which it explained above, while turning off the open/close switch SW1 in the drive circuit 40 and stopping energization of the minute current iCP to the Vs cel 6, and pump current control if processing is started (time t1) as shown in drawing 9 , an open/close switch SW2 is turned on and constant current is passed to hard flow in the minute current iCP to the Vs cel 6. And if fixed time amount T1 passes after that (time t2), the porous electrode 6c side electrical potential difference Vs at that time will be set up as a resistance detection electrical potential difference VS 2, and the internal resistance RVS of the Vs cel 6 from deflection **Vs of

this resistance detection electrical potential difference VS 2 and the porous electrode 6c side electrical potential difference Vs (that is, the basic detection electrical potential difference VS 1) at the time of the detection processing starting concerned will be detected. Hereafter, this reason is explained.

[0111] First, when the constant current for internal resistance detection is passed in the Vs cel 6, the porous electrode 6c side electrical potential difference Vs of the Vs cel 6 changes not only with the internal resistance RVS of the Vs cel 6 but with the electromotive force generated according to the ratio of the oxygen density by the side of each electrode 6b and 6c. Then, in order that the porous electrode 6c side electrical potential difference Vs for internal resistance detection may make effect of this electromotive force hard to be influenced, he passes a bigger current than the minute current iCP, and is trying for the voltage drop by the internal resistance RVS of the Vs cel 6 to become large in this example.

[0112] Moreover, since the oxygen density by the side of each electrode 6b of the Vs cel 6 and 6c becomes abbreviation regularity by pump current control and energization of the minute current iCP, respectively, the electromotive force of the Vs cel 6 also becomes abbreviation regularity. therefore -- even if it passes constant current in the Vs cel 6 and detects the porous electrode 6c side electrical potential difference Vs (namely, VS2) at that time -- the internal resistance RVS of this electrical-potential-difference value to the Vs cel 6 -- abbreviation -- it can ask correctly.

[0113] However, more strictly, since the oxygen density in the 1st test chamber 20 is controlled by feedback control of a pump current, it is changed according to the response delay of a control system etc., and is not fixed to fixed concentration. Moreover, the oxygen density in the 1st test chamber 20 changes also with the temperature of the NOx sensor 2. Therefore, when it asks for internal resistance RVS from the electrical potential difference Vs detected by passing the constant current for internal resistance RVS detection in the Vs cel 6, although it is [some], an error will arise in internal resistance RVS.

[0114] Then, in this example, in order to enable it to detect more the internal resistance RVS of the Vs cel 6, as a result a chip temperature to accuracy The variation (deflection **Vs) of the porous electrode 6c side electrical potential difference Vs after passing the constant current for internal resistance RVS detection in the Vs cel 6 until it carries out predetermined time (for example, 60microsec.) progress is detected. Even if it is the case where the oxygen density in the 1st test chamber 20 has shifted from target concentration by asking for deflection **Vs to this internal resistance RVS, it enables it to ask for the internal resistance RVS of the Vs cel 6, as a result a chip temperature correctly.

[0115] In addition, what is necessary is to set up beforehand the map which memorized internal resistance RVS corresponding to deflection **Vs, and just to compute internal resistance RVS using this map, if it hits computing this internal resistance RVS. Next, again in internal resistance detection processing of this example The time of predetermined time (for example, 40microsec.) passing further after that, and the elapsed time after the detection processing starting concerned amounting to T2, if fixed time amount T1 passed after starting and the resistance detection electrical potential difference VS 2 was set up (time t2) by t3 By turning off the open/close switch SW2 of the drive circuit 40, and turning on an open/close switch SW3 Constant current is passed in the minute current iCP and this direction in the Vs cel 6, and further, if fixed time amount (for example, 100microsec.) passes and the elapsed time after the detection processing starting concerned reaches T3 (time t4), an open/close switch SW3 is turned off.

[0116] Consequently, by could return promptly the oxygen pumped out of the lock out space by the side of porous electrode 6c of the Vs cel 6 for detection of internal resistance RVS in this example, and having passed the current to hard flow in iCP Since the internal polarization condition of the Vs cel 6 of having changed can be restored, the lock out space by the side of porous electrode 6c can be promptly operated as a source of internal reference oxygen, and the Vs cel 6 can be promptly operated as an oxygen density measurement cel. Therefore, it becomes possible to detect the internal resistance RVS of the Vs cel 6 with high precision, without being able to make time amount T four until it starts actuation of density measurement into time amount very short like 500microsec. after the processing starting concerned, and affecting measurement of an oxygen density and NOx concentration.

[0117] As explained above, it sets to the oxygen density and nitrogen-oxides density measurement equipment of this example. So that the temperature of the NOx sensor 2 may be detected from the internal resistance RVS of the Vs cel 6 which detects the oxygen density of the 1st test chamber 20 and this temperature may turn into target temperature (for example, 850 degrees C) Control the amount of energization currents to heaters 12 and 14, and moreover, when the chip temperature obtained from the detected internal resistance RVS or this internal resistance RVS separates from desired value It is made to carry out temperature compensation of the measurement result of NOx concentration and an oxygen density by amending the 2nd pump current IP 2 which expresses the measurement result of NOx concentration and an oxygen density with the amount of temperature compensation according to the deflection, and the 1st pump current IP 1, respectively. For this reason, according to the oxygen density and nitrogen-oxides density measurement equipment of this example, an oxygen density and NOx concentration can be detected with high precision, without being influenced by the temperature of the NOx sensor 2.
[0118] Moreover, especially, by this example, while the laminating of the NOx sensor 2 is carried out to the order of the 1st pump cel 4, the Vs cel 6, and the 2nd pump cel 8 When the laminating of the heaters 12 and 14 is carried out to the direction both sides of a laminating and the NOx sensor 2 is moreover projected [the] from a laminating 4d of diffusion limitation layers and the diffusion limitation layers 6d and 22d lap, and the heater wiring 12b and 14b of heaters 12 and 14 is arranged so that each [these] diffusion limitation layer may be pinched in an abbreviation center position. Therefore, in this example, the measured gas which can heat each cels 4-8 efficiently using heaters 12 and 14, and flows in the 1st test chamber 20 and the 2nd test chamber 26 through each diffusion limitation layer according to the structure of such an NOx sensor 2 can also be efficiently heated now. For this reason, according to this example, by controlling the temperature of the Vs cel 6, it becomes possible to control more certainly the temperature of each cel which constitutes the NOx sensor 2 to target temperature, and it can improve the accuracy of measurement of an oxygen density and NOx concentration.
[0119] In addition, if a sample and hold circuit is established in the input stage to the differential amplifier AMP and it is made to carry out sample hold of the porous electrode 6c side electrical potential difference Vs before measurement initiation of a chip temperature for example, the differential amplifier AMP will be operated with the electrical-potential-difference value which carried out sample hold, and current control of the 1st pump cel 4 can be made to maintain also during measurement of a chip temperature during measurement of a chip temperature, in this example, although it was made to suspend the current control to the 1st pump cel 4.

[Translation done.]

* NOTICES *

EXAMPLE

[Example] One example of this invention is explained with a drawing below. The outline block diagram with which drawing 1 expresses the configuration of the whole oxygen density and nitrogen-oxides density measurement equipment of an example with which this invention was applied, and drawing 2 are the decomposition perspective views of the NOx sensor 2 used in this measuring device. The 1st oxygen pumping cel from which the measuring device of this example constitutes the NOx sensor 2 and the NOx sensor 2 as shown in drawing 1 (It is hereafter called the 1st pump cel) While performing the energization to 4 and the oxygen density measurement cel (henceforth Vs cel) 6, and a switch of an energization path The drive circuit 40 which detects the current (henceforth the 1st pump current) IP 1 which flows in the 1st pump cel 4, The detector 42 which detects the current (henceforth the 2nd pump current) IP 2 which impresses a constant voltage to the 2nd oxygen pumping cel (henceforth the 2nd pump cel) 8 which constitutes the NOx sensor 2, and flows then, While controlling the heater energization circuit 44 which it energizes [circuit] to the heaters 12 and 14 of the pair prepared in the NOx sensor 2, and makes each cels 4, 6, and 8 heat, and the drive circuit 40 and the heater energization circuit 44 Detecting signals [VIP / VIP and / 2] 1 from the drive circuit 40 and a detector 42 It consists of electronic control circuits (henceforth ECU) 50 which are based and calculate the oxygen density and NOx concentration in measured gas and which consist of a microcomputer.
[0061] As shown in drawing 2 , it sets in the NOx sensor 2. The 1st pump cel 4 Form the rectangle-like porous electrodes 4b and 4c and lead section 4bl of those, and 4cl, and further, a round hole is drilled in the both sides of solid electrolyte layer 4a formed in tabular at solid electrolyte layer 4a, respectively so that a part for the core of porous electrodes 4b and 4c may be penetrated. By putting a porous filler in the round hole, 4d of diffusion limitation layers is formed.
[0062] The Vs cel 6 moreover, on both sides of solid electrolyte layer 4a of the 1st pump cel 4, and isomorphism-like solid electrolyte layer 6a 6d of diffusion limitation layers is formed by forming the porous electrodes 6b and 6c of a circle configuration and lead section 6bl of those, and 6cl, drilling a round hole in solid electrolyte layer 6a further, respectively so that a part for the core of porous electrodes 6b and 6c may be penetrated, and putting a porous filler in the round hole.
[0063] And when the center position on solid electrolyte layer 4a and 6a carries out abbreviation coincidence of the porous electrodes 6b and 6c of this Vs cel 6, and the porous electrodes 4b and 4c of the 1st pump cel 4 and the laminating of the Vs cel 6 and the 1st pump cel 4 is carried out, he is trying for 4d to counter mutually 6d of each diffusion limitation layer. Moreover, the porous electrodes 6b and 6c of the circle configuration formed in the Vs cel 6 are smaller than the porous electrodes 4b and 4c of the shape of a rectangle formed in the 1st pump cel 4. Moreover, in the front rear face of the Vs cel 6, in order to prevent the current leak from lead section 6bl and 6cl lead section 6bl and 6cl -- the wrap from an outside -- the insulator layer which consists of an alumina etc. like forms -- having -- **** -- moreover -- each -- in lead section 6bl and 6cl 6f of exsorption resistance sections which make a part of oxygen poured into the porous electrode 6c side by the below-mentioned energization control leak to the porous electrode 6b side is formed.
[0064] Thus, the laminating of the 1st pump cel 4 and the Vs cel 6 which were formed is carried out through each above-mentioned solid electrolyte layers 4a and 6a and the isomorphism-like solid electrolyte layer 18. And the hole of the shape of a bigger rectangle than porous electrode 4c is drilled in the opposite location with each porous electrodes 4c and 6b of this solid electrolyte layer

18, and this hole functions as the 1st test chamber 20.
[0065] Moreover, the laminating of each above-mentioned solid electrolyte layers 4a and 6a and the isomorphism-like solid electrolyte layer 22 is carried out also to the porous electrode 6c side of the Vs cel 6. And 22d of diffusion limitation layers is formed in this solid electrolyte layer 22 by drilling the round hole of this dimension in 6d of diffusion limitation layers and homotopic of the Vs cel 6, and putting a porous filler in that round hole.
[0066] On the other hand, the 2nd pump cel 8 forms the rectangle-like porous electrodes 8b and 8c and lead section 8bl of those, and 8cl in the both sides of solid electrolyte layer 8a formed in tabular like the 1st pump cel 4, respectively. And the laminating of this 2nd pump cel 8 is carried out to the solid electrolyte layer 22 through the solid electrolyte layer 18 and the solid electrolyte layer 24 completely formed similarly. Consequently, the hole of the shape of a rectangle drilled by the solid electrolyte layer 24 will function as the 2nd test chamber 26.
[0067] And the NOx sensor 2 except heaters 12 and 14 is produced by sintering at predetermined temperature, after carrying out the laminating of each part of the above and unifying. Moreover, predetermined spacing is opened with spacers 28 and 29, and the laminating of the heaters 12 and 14 is carried out to the both sides of the layered product of the 1st pump cel 4 by which a laminating is carried out in this way, the Vs cel 6, and the 2nd pump cel 8, i.e., the outside of the 1st pump cel 4 and the 2nd pump cel 8, respectively.
[0068] These heaters 12 and 14 with each above-mentioned solid electrolyte layers 4a and 6a and -- The isomorphism-like heater substrates 12a and 14a, It consists of the heater wiring 12b and 14b formed in the opposed face side with each above-mentioned cels 4 and 8 of each heater substrates 12a and 14a and lead section 12bl of those, and 14bl. Spacers 28 and 29 With the porous electrodes 4b and 8c of the 1st pump cel 4 and the 2nd pump cel 8, these heater wiring 12b and 14b is arranged at the lead section 12bl [of the heater wiring 12b and 14b], and 14bl side, respectively so that it may counter mutually through a gap.
[0069] The heater substrates 12a and 14a are made of the alumina, and screen-stencil, calcinate and form in the sheet of an alumina what heater wiring mixed the alumina to platinum powder, and was made into the shape of a paste. In addition, an alumina sheet serves as the heater substrates 12a and 14a and spacers 28 and 29 by baking. And it is joined using ceramic system adhesives from both sides of the already calcinated 1st pump cel 4 and the 2nd pump cel 8, and heaters 12 and 14 serve as the perfect NOx sensor 2.
[0070] Here, as each above-mentioned solid electrolyte layers 4a and 6a and a solid electrolyte ingredient which constitutes --, although a zirconia, the solid solution and the zirconia of yttria, and the solid solution of calcia are typical, the solid solution of hafnia, the perovskite mold oxide solid solution, the trivalent metal oxide solid solution, etc. can be used for others. Moreover, it is desirable to use the platinum which has a catalyst function, and a rhodium or its alloy for the porous electrode prepared in the front face of each solid electrolyte layers 4a, 6a, and 8a. And as the formation approach, what mixed a solid electrolyte layer and the powder of the same ingredient to platinum powder, for example is made into the shape of a paste, it screen-stencils on a solid electrolyte layer, and the thick-film formation approach subsequently sintered and the coat formation approach by vacuum evaporationo are learned. Moreover, as for the diffusion limitation layers 4d, 6d, and 22d, it is desirable to use the ceramics which has a thin through tube, and porous ceramics.
[0071] On the other hand, heater wiring 12b and 14b of heaters 12 and 14 is used as the composite material of the ceramics, platinum, or a platinum alloy, and in order to fall resistance and to reduce the electric loss in the lead section, considering as platinum or a platinum alloy is desirable [the lead section 12bl and 14bl]. Moreover, an alumina, a spinel, forsterite, a steatite, a zirconia, etc. can be used for the heater substrates 12a and 14a and spacers 28 and 29.
[0072] Next, as shown in drawing 1 , the porous electrodes 4c and 6b by the side of the 1st test chamber 20 of the 1st pump cel 4 of the NOx sensor 2 and the Vs cel 6 are grounded through the resistor R1, and the porous electrodes 4b and 6c of another side are connected to the drive circuit 40. The resistor R2 by which, as for the drive circuit 40, the constant voltage VCP was impressed to the end, and the other end was connected to porous electrode 6c of the Vs cel 6 through the open/close switch SW1, - the differential amplifier AMP by which porous electrode 6c of the Vs cel 6 was connected to the side input terminal through the open/close switch SW1, reference voltage VCO was

impressed to + side input terminal, and the output terminal was connected to porous electrode 4b of the 1st pump cel 4 through the resistor R0 -- since -- it has becoming control-section 40a.
[0073] This control-section 40a operates as follows, when an open/close switch SW1 is in an ON state. First, the oxygen in the 1st test chamber 20 is poured into the porous electrode 6c side of the Vs cel 6 by passing the fixed minute current iCP in the Vs cel 6 through a resistor R2. Since this porous electrode 6c is open for free passage the porous electrode 6b side through 6f of exsorption resistance sections while being blockaded by the solid electrolyte layer 22, the lock out space in porous electrode 6c serves as a fixed oxygen density by energization of the minute current iCP, and it functions as an internal oxygen reference standard.
[0074] Moreover, if the porous electrode 6c side of the Vs cel 6 functions as an internal oxygen reference standard in this way, in the Vs cel 6, the electromotive force according to the ratio of the oxygen density in the 1st test chamber 20 and the oxygen density by the side of an internal oxygen reference standard will occur, and the porous electrode 6c side electrical potential difference Vs will turn into an electrical potential difference according to the oxygen density in the 1st test chamber 20 at it. And since this electrical potential difference is inputted into the differential amplifier AMP, from the differential amplifier AMP, the electrical potential difference according to the deflection (VCO-input voltage) of reference voltage VCO and its input voltage is outputted, and this output voltage is impressed to porous electrode 4b of the 1st pump cel 4 through a resistor R0.
[0075] Consequently, the 1st pump current IP 1 flows in the 1st pump cel 4, and it is controlled so that the electromotive force generated in the Vs cel 6 according to this 1st pump current IP 1 serves as a fixed electrical potential difference (it becomes fixed concentration like [if it puts in another way / the oxygen density in the 1st test chamber 20]). That is, when it functions as a pump current control means and measured gas has flowed in the 1st test chamber 20 through 4d of diffusion limitation layers, this control-section 40a controls the oxygen density in the 1st test chamber 20 so that the oxygen density in the 1st test chamber 20 turns into fixed concentration.
[0076] In addition, the oxygen density in the 1st test chamber 20 controlled in this way is set up so that energization of the 1st pump current IP 1 may not decompose the NOx component in the measured gas in the 1st test chamber 20 and oxygen may serve as hypoxia concentration (for example, about 1000 ppm) which exists for a while, and the value of 100mV - about 200mV is set to the reference voltage VCO which determines this oxygen density. Moreover, the resistor R0 prepared between the output of the differential amplifier AMP and porous electrode 4b is for detecting the 1st pump current IP 1, and it is the both-ends electrical potential difference VIP 1. It is inputted into ECU50 as a detecting signal of the 1st pump current IP 1.
[0077] In the drive circuit 40, at the above-mentioned control-section 40a Next, in addition, current regulator circuit 40b which is connected to porous electrode 6c of the Vs cel 6 through an open/close switch SW2, and passes constant current to hard flow in the above-mentioned minute current iCP among porous electrode 6b-6c, It connects with porous electrode 6c of the Vs cel 6 through an open/close switch SW3, and has current regulator circuit 40c which passes constant current in the above-mentioned minute current iCP and this direction among porous electrode 6b-6c.
[0078] Each [these] current regulator circuits 40b and 40c are for detecting the internal resistance RVS of the Vs cel 6. And in order to enable it for energization of this constant current to detect the internal resistance RVS of the Vs cel 6 by the ECU50 side, the porous electrode 6c side electrical potential difference Vs is inputted into ECU50. In addition, the constant current which each current regulator circuits 40b and 40c pass is set as the same current value only by the directions of a current differing. And this current value is larger than the minute current iCP supplied to the Vs cel 6 through a resistor R2.
[0079] Moreover, the open/close switches SW1-SW3 formed, respectively between control-section 40a, current regulator circuits 40b and 40c, and porous electrode 6c of the Vs cel 6 are turned on and off by the control signal from ECU50, and perform measurement actuation of an oxygen density and NOx concentration. Usually, only when only an open/close switch SW1 will be in an ON state, control-section 40a operates and it sometimes detects the internal resistance RVS of the Vs cel 6, an open/close switch SW1 will be in an OFF state, and open/close switches SW2 and SW3 are controlled by the ON state in order.
[0080] On the other hand, between porous electrode 8b of the 2nd pump cel 8 of the NOx sensor 2,

and 8c, a constant voltage VP 2 is impressed through the resistor R3 as a constant-voltage impression means to constitute the above-mentioned detector 42. In the 2nd pump cel 8, a current flows from porous electrode 8c to the 8b side, and as for the impression direction of this constant voltage VP 2, the porous electrode 8c side is set up so that the positive-electrode and porous electrode 8b side may serve as a negative electrode, so that the oxygen in the 2nd test chamber 26 may be pumped out outside. Moreover, this constant voltage VP 2 decomposes the NOx component in the measured gas of the 2nd measurement interior of a room which flows through the diffusion limitation layers 6d and 22d from the 1st test chamber 20, and is set to the electrical potential difference which can pump out that oxygen component, for example, 450mV.

[0081] In addition, it is an electrical potential difference VIP 2 about the 2nd pump current IP 2 to which a resistor R3 flows in the 2nd pump cel 8 by impression of this constant voltage VP 2. It is for changing and inputting into ECU50 as a detecting signal of the 2nd pump current IP 2. Thus, it sets to the oxygen density and nitrogen-oxides density measurement equipment of constituted this example. If the open/close switch SW1 in the drive circuit 40 is turned on and open/close switches SW2 and SW3 are turned off The oxygen density in the 1st test chamber 20 into which measured gas flows through 4d (the 1st diffusion limitation layer) of diffusion limitation layers is controlled by actuation of control-section 40a by the fixed oxygen density. Since the measured gas in the 1st test chamber 20 controlled by the fixed oxygen density flows into the 2nd test chamber 26 through the diffusion limitation layers (the 2nd diffusion limitation layer) 6d and 22d, The 1st pump current IP 1 which flows in the 1st pump cel 4 changes according to the oxygen density in measured gas. The 2nd pump current IP 2 which flows in the 2nd pump cel 8 comes to change according to the NOx concentration in measured gas. Detecting signals VIP1 and VIP2 which express each [these] currents IP1 and IP2 with the ECU50 side The oxygen density and NOx concentration in measured gas can be measured by reading and performing predetermined data processing.

[0082] By the way, it is necessary to control uniformly the temperature of each above-mentioned cels 4, 6, and 8, and the temperature of the Vs cel 6 which detects the oxygen density in the 1st test chamber 20 especially, and for that, in order to secure the accuracy of measurement of each [these] concentration, it is necessary to control the amount of energization currents from the heater energization circuit 44 to each heaters 12 and 14 so that the temperature of the Vs cel 6 turns into target temperature. So, in ECU50, by switching the on-off condition of the above-mentioned open/close switches SW1-SW3, the temperature of the Vs cel 6 is detected from that internal resistance RVS, and the amount of energization from the heater energization circuit 44 to heaters 12 and 14 is controlled by this example so that this detected internal resistance RVS serves as constant value (that is, the temperature of the Vs cel 6 target temperature).

[0083] Hereafter, the control processing performed in ECU50 for such temperature control and density measurement is explained along with the flow chart shown in drawing 3 and drawing 4 . In addition, in order that drawing 3 may measure an oxygen density and NOx concentration, the oxygen density and NOx density measurement processing repeatedly performed in ECU50 are expressed, and drawing 4 expresses the internal resistance detection processing performed in ECU50 as interrupt processing of every fixed time amount T0 (for example, 1sec.), in order to detect the internal resistance RVS of the Vs cel 6 and to control the energization to heaters 12 and 14.

[0084] As shown in drawing 3 , in an oxygen density and NOx density measurement processing, activation judging processing in which it waits to activate the NOx sensor 2 is first performed after starting of the measuring device concerned S100 (S expresses a step) by judging whether the NOx sensor 2 was activated by energization to heaters 12 and 14.

[0085] This activation judging processing is performed by judging whether the internal resistance RVS of the Vs cel 6 detected by the below-mentioned internal resistance detection processing became below the activation decision value set up beforehand. That is, as shown in drawing 5 , since the internal resistance RVS of the Vs cel 6 decreases as a chip temperature rises and the Vs cel 6 is activated, after energization starting to heaters 12 and 14, it judges whether the chip temperature reached predetermined activation temperature by S100 by judging whether the internal resistance RVS of the Vs cel 6 became below an activation decision value.

[0086] Moreover, although the open/close switch SW1 in the drive circuit 40 is controlled by the ON state and open/close switches SW2 and SW3 are controlled by initialization processing which is not

illustrated by the OFF state immediately after starting of the measuring device concerned, actuation of the differential amplifier AMP in the drive circuit 40 stops until the NOx sensor 2 goes up even near the activation temperature by activation judging processing of the above S100. This is because the internal resistance RVS of the Vs cel 6 is large, so an overcurrent will flow in the 1st pump cel 4 if the porous electrode 6c side electrical potential difference Vs inputted into the differential amplifier AMP becomes high too much and the differential amplifier AMP is operated in the condition that the NOx sensor 2 is not being activated.
[0087] Next, detecting signal VIP 2 which will shift to S110 and will be inputted from the resistor R3 of a detector 42 if it is judged that the NOx sensor 2 was activated in S100 By reading, processing as a nitrogen-oxides density measurement means to detect the 2nd pump current IP 2 is performed. Moreover, detecting signal VIP 1 inputted from the resistor R0 of the drive circuit 40 in S120 continuing By reading, processing as an oxygen density measurement means to detect the 1st pump current IP 1 is performed.
[0088] And in S130 continuing, the amount of criteria amendments to the 2nd pump current IP 2 is computed based on the detected 1st pump current IP 1. That is, in this example, since the oxygen density in the 1st test chamber 20 is controlled by pump current control by the above-mentioned drive circuit 40 to hypoxia concentration not to decompose the NOx component in the measured gas in the 1st test chamber 20, not only NOx in measured gas but oxygen flows into the 2nd test chamber 26. Therefore, although the 2nd pump current IP 2 changes corresponding to the NOx concentration in measured gas, the effect of the oxygen density in measured gas also receives it. Although an example of the measurement result of the 1st pump current IP 1 at the time of drawing 6 making measured gas the gas for a trial which does not contain NOx, and operating the equipment concerned, and the 2nd pump current IP 2 is expressed The 1st pump current IP 1 changes with a fixed inclination corresponding to the oxygen density in measured gas, and the 2nd pump current IP 2 changes in response to the effect of the oxygen density in measured gas so that clearly also from this drawing.
[0089] Then, in this example, in order to make the 2nd pump current IP 2 correspond only to the NOx concentration in measured gas The value of the 2nd pump current IP 2 corresponding to the oxygen density obtained when the measured gas which does not contain NOx as mentioned above is measured Memorize beforehand to storages, such as ROM, as an offset value for 2nd pump current IP2 amendment, and the oxygen density in measured gas is detected from the 1st pump current IP 1. He reads the offset value corresponding to this oxygen density out of the offset value data memorized beforehand, and is trying to set it up as the above-mentioned amount of criteria amendments.
[0090] In addition, in case this amount of criteria amendments is actually computed, the map which memorized the offset value (that is, the amount of criteria amendments) corresponding to the 1st pump current IP 1 is used, and the amount of direct criteria amendments is calculated from the 1st pump current IP 1 by searching this map by making the 1st pump current IP 1 into a parameter.
[0091] In this way, if the amount of criteria amendments is computed, it will shift to S140 shortly and the internal resistance RVS of the Vs cel 6 obtained by the below-mentioned internal resistance detection processing will be read. And in S150 continuing, the amount of temperature compensation to the 2nd pump current IP 2 is computed based on this read internal resistance RVS.
[0092] That is, although the energization to heaters 12 and 14 is controlled by this example so that the internal resistance RVS of the Vs cel 6 is detected and the internal resistance RVS serves as a predetermined value in the below-mentioned internal resistance detection processing (the temperature of the NOx sensor 2 will turn into predetermined target temperature if it puts in another way like) When the temperature of measured gas changes suddenly, temperature control cannot be made to follow the temperature change of measured gas, but the temperature of the NOx sensor 2 may change with the temperature changes of measured gas.
[0093] For example, that the NOx concentration under an internal combustion engine's exhaust air should be measured using the measuring device of this example, drawing 7 attaches the NOx sensor 2 in an internal combustion engine's exhaust pipe, and expresses an example of the measurement result of having measured the temperature change of the NOx sensor 2 at the time of operating the equipment concerned. So that clearly from this drawing in the measuring device of this example If

an exhaust-gas temperature falls temporarily or an exhaust-gas temperature rises temporarily with reduction of an inhalation air content with increase of an inhalation air content at the time of moderation of an internal combustion engine at the time of acceleration of an internal combustion engine in spite of performing the below-mentioned temperature control In response to the effect of the temperature change, both the 1st pump current IP 1 and the 2nd pump current IP 2 change, and the NOx sensor 2 will require the time amount also for about 1 minute, by the time especially the 2nd pump current IP 2 returns to a stable state. In addition, this is for returning the oxygen density to target concentration after that to take time amount, once the oxygen density in the 1st test chamber 20 shifts from target concentration, when the 1st pump current IP 2 is influenced of an exhaust-gas temperature.

[0094] Then, even if the temperature of measured gas changes suddenly, in order to enable it to measure NOx concentration correctly from the 2nd pump current IP 2, he searches for the temperature of the Vs cel 6 from the internal resistance RVS of the Vs cel 6, for example, is trying to ask drawing 8 for the amount of temperature compensation to the 2nd pump current IP 2 in this example using the map for the amount calculation of **** temperature compensation.

[0095] In addition, although the map shown in drawing 8 is set up so that the amount of temperature compensation may be calculated from the chip temperature of the Vs cel 6, it can calculate the amount of direct temperature compensation from internal resistance RVS, without converting internal resistance RVS into temperature, if the map for the amount calculation of temperature compensation which makes a parameter internal resistance RVS of the Vs cel 6 is set up beforehand. Moreover, for example, the map which makes a parameter deflection of a chip temperature and target temperature (target temperature is 850 degrees C in drawing 8) is set up beforehand. You may make it calculate the amount of temperature compensation from the gap (deflection) from the target temperature of a chip temperature. The map which makes a parameter deflection of internal resistance RVS and the target resistance corresponding to target temperature is set up beforehand, and you may make it calculate the amount of temperature compensation from the gap (deflection) from the target resistance of internal resistance RVS.

[0096] Next, if the amount of temperature compensation is computed in S150, it will shift to S160 and the 2nd pump current IP 2 will be amended by adding the amount of criteria amendments, and the amount of temperature compensation to the 2nd pump current IP 2 detected by S110. And in S170 continuing, the 2nd pump current IP 2 after this amendment is outputted to external devices (engine control system etc.) as a measurement result of NOx concentration.

[0097] Next by S180, the amount of temperature compensation to the 1st pump current IP 1 is computed again based on the internal resistance RVS read by S140. And using this computed amount of temperature compensation, the 1st pump current IP 1 detected by S120 is amended, and in S200 continuing, the 1st pump current IP 1 after this amendment is outputted to an external device as a measurement result of an oxygen density, and it shifts to S110 again S190 continuing.

[0098] In addition, processing of S180 and S190 is processing for making the 1st pump current IP 1 correspond to the oxygen density in measured gas, without being influenced by the temperature change of the NOx sensor 2, and computes the amount of temperature compensation to the 1st pump current IP 1 like the above S150 in S180 using the map set up beforehand.

[0099] And in this example, processing of S150, S160, S180, and S190 which are performed in order to amend the 2nd pump current IP 2 corresponding to NOx concentration and the 1st pump current IP 1 corresponding to an oxygen density according to the temperature of the Vs cel 6, respectively is equivalent to the amendment means of this invention.

[0100] By this example, it sets here to above-mentioned oxygen density and NOx density measurement processing. The amount of criteria amendments for amending the 2nd pump current IP 2 according to the oxygen density in measured gas based on the 1st pump current IP 1, Although explained as what calculates the amount of temperature compensation for amending the 2nd pump current IP 2 according to the temperature of the Vs cel 6 separately, and amends the 2nd pump current IP 2 For example, by setting up the map for the amount calculation of criteria amendments, and switching the map used for calculation of the amount of criteria amendments according to the temperature of the Vs cel 6 for every temperature of the Vs cel 6 You may make it calculate the amount of amendments for amending the 2nd pump current IP 2 according to the oxygen density in

measured gas, and the temperature of the Vs cel 6. The two-dimensional map for the amount calculation of amendments which makes a parameter the 1st pump current IP 1 and temperature (or internal resistance RVS) of the Vs cel 6 is set up beforehand, and you may make it calculate the amount of amendments to the 2nd pump current IP 2 using this map.

[0101] Next, the internal resistance detection processing shown in drawing 4 is explained. In addition, not only the function as a temperature detection means to only detect the internal resistance RVS of the Vs cel 6 but the function as a heater energization control means which controls the amount of energization currents to heaters 12 and 14 through the heater energization circuit 44 from that detection result has this internal resistance detection processing.

[0102] If this processing is started as shown in drawing 4 , in S210, the porous electrode 6c side electrical potential difference Vs of the Vs cel 6 will be read, and this will be set up as a basic detection electrical potential difference VS 1 of the Vs cel 6. And in S220 continuing, constant current is passed in the minute current iCP to the Vs cel 6 to hard flow (that is, direction which pours oxygen into the 1st test-chamber 20 side from the lock out space side which had become an internal oxygen reference standard until now) by turning off the open/close switch SW1 made into the ON state for density measurement, and turning on the open/close switch SW2 connected to current regulator circuit 40b.

[0103] Moreover, in S230 continuing, after starting of the detection processing concerned, if waiting and predetermined time T1 pass that predetermined time T1 passes by judging whether predetermined time T1 (for example, 60microsec.) passed, the porous electrode 6c side electrical potential difference Vs of the Vs cel 6 will be read, and this will be set up S240 as a resistance detection electrical potential difference VS 2 of the Vs cel 6.

[0104] In this way, by shifting to S250 and judging whether predetermined time T2 (for example, 100microsec.) passed after starting of the detection processing concerned, if the resistance detection electrical potential difference VS 2 is set up When waiting and predetermined time T2 pass, that predetermined time T2 passes in S260 By turning off the open/close switch SW2 used as the ON state between fixed time amount T2 after starting of the detection processing concerned, and turning on the open/close switch SW3 connected to current regulator circuit 40c Constant current is passed in the Vs cel 6 in the minute current iCP and this direction (that is, direction which pours the oxygen in the 1st test chamber 20 into a lock out space side).

[0105] Thus, if waiting and predetermined time T3 pass that predetermined time T3 passes by shifting to S270 and judging whether predetermined time T3 (for example, 200microsec.) passed after starting of the detection processing concerned this time if an open/close switch SW3 is turned on, an open/close switch SW3 is turned off in S280. Consequently, the open/close switches SW1-SW3 in the drive circuit 40 will be in an OFF state altogether.

[0106] And in S290 continuing, deflection **Vs (=VS1-VS2) of the basic detection electrical potential difference VS 1 set up immediately after starting of the detection processing concerned and the resistance detection electrical potential difference VS 2 set up after predetermined time T1 progress is calculated, and it shifts to S310 which computes the internal resistance RVS of this Vs cel 6 from deflection **Vs, and continues in S300. In addition, the calculation technique of the internal resistance RVS in this example is explained in detail later.

[0107] The deflection of the internal resistance RVS of the Vs cel 6 and desired value which carried out [above-mentioned] calculation in S310, Or it is based on the deflection of the temperature of the Vs cel 6 and target temperature which are acquired from internal resistance RVS. The control signal (heater control signal) the increase of the amount of energization currents to heaters 12 and 14 and for carrying out a decrease is outputted to the heater energization circuit 44, and processing as a heater energization control means which controls the amount of currents supplied to heaters 12 and 14 from the heater energization circuit 44 is performed.

[0108] in addition, in this heater energization control, when energization and un-energizing to heaters 12 and 14 are constituted from a switching circuit which can be switched to a high speed, the heater energization circuit 44 That what is necessary is just to control the duty ratio of the driving pulse which switches its energization and un-energizing Moreover, what is necessary is just to make it fluctuate an electrical potential difference based on the heater control signal from ECU50, when the output voltage to heaters 12 and 14 is constituted for the heater energization circuit 44 from a

controllable armature-voltage control circuit.
[0109] When a heater control signal is outputted in this way, and shortly By shifting to S320 and judging whether predetermined time T four (for example, 500microsec.) passed after starting of the detection processing concerned When waiting and predetermined time T four pass that predetermined time T four passes, measurement actuation of an oxygen density and NOx concentration is made to resume by turning on the open/close switch SW1 used as the OFF state between fixed time amount T four after starting of the detection processing concerned, and ending the detection processing concerned in S330.
[0110] In internal resistance detection processing in which it explained above, while turning off the open/close switch SW1 in the drive circuit 40 and stopping energization of the minute current iCP to the Vs cel 6, and pump current control if processing is started (time t1) as shown in drawing 9 , an open/close switch SW2 is turned on and constant current is passed to hard flow in the minute current iCP to the Vs cel 6. And if fixed time amount T1 passes after that (time t2), the porous electrode 6c side electrical potential difference Vs at that time will be set up as a resistance detection electrical potential difference VS 2, and the internal resistance RVS of the Vs cel 6 from deflection **Vs of this resistance detection electrical potential difference VS 2 and the porous electrode 6c side electrical potential difference Vs (that is, the basic detection electrical potential difference VS 1) at the time of the detection processing starting concerned will be detected. Hereafter, this reason is explained.
[0111] First, when the constant current for internal resistance detection is passed in the Vs cel 6, the porous electrode 6c side electrical potential difference Vs of the Vs cel 6 changes not only with the internal resistance RVS of the Vs cel 6 but with the electromotive force generated according to the ratio of the oxygen density by the side of each electrode 6b and 6c. Then, in order that the porous electrode 6c side electrical potential difference Vs for internal resistance detection may make effect of this electromotive force hard to be influenced, he passes a bigger current than the minute current iCP, and is trying for the voltage drop by the internal resistance RVS of the Vs cel 6 to become large in this example.
[0112] Moreover, since the oxygen density by the side of each electrode 6b of the Vs cel 6 and 6c becomes abbreviation regularity by pump current control and energization of the minute current iCP, respectively, the electromotive force of the Vs cel 6 also becomes abbreviation regularity. therefore -- even if it passes constant current in the Vs cel 6 and detects the porous electrode 6c side electrical potential difference Vs (namely, VS2) at that time -- the internal resistance RVS of this electrical-potential-difference value to the Vs cel 6 -- abbreviation -- it can ask correctly.
[0113] However, more strictly, since the oxygen density in the 1st test chamber 20 is controlled by feedback control of a pump current, it is changed according to the response delay of a control system etc., and is not fixed to fixed concentration. Moreover, the oxygen density in the 1st test chamber 20 changes also with the temperature of the NOx sensor 2. Therefore, when it asks for internal resistance RVS from the electrical potential difference Vs detected by passing the constant current for internal resistance RVS detection in the Vs cel 6, although it is [some], an error will arise in internal resistance RVS.
[0114] Then, in this example, in order to enable it to detect more the internal resistance RVS of the Vs cel 6, as a result a chip temperature to accuracy The variation (deflection **Vs) of the porous electrode 6c side electrical potential difference Vs after passing the constant current for internal resistance RVS detection in the Vs cel 6 until it carries out predetermined time (for example, 60microsec.) progress is detected. Even if it is the case where the oxygen density in the 1st test chamber 20 has shifted from target concentration by asking for deflection **Vs to this internal resistance RVS, it enables it to ask for the internal resistance RVS of the Vs cel 6, as a result a chip temperature correctly.
[0115] In addition, what is necessary is to set up beforehand the map which memorized internal resistance RVS corresponding to deflection **Vs, and just to compute internal resistance RVS using this map, if it hits computing this internal resistance RVS. Next, again in internal resistance detection processing of this example The time of predetermined time (for example, 40microsec.) passing further after that, and the elapsed time after the detection processing starting concerned amounting to T2, if fixed time amount T1 passed after starting and the resistance detection electrical potential

difference VS 2 was set up (time t2) by t3 By turning off the open/close switch SW2 of the drive circuit 40, and turning on an open/close switch SW3 Constant current is passed in the minute current iCP and this direction in the Vs cel 6, and further, if fixed time amount (for example, 100microsec.) passes and the elapsed time after the detection processing starting concerned reaches T3 (time t4), an open/close switch SW3 is turned off.

[0116] Consequently, by could return promptly the oxygen pumped out of the lock out space by the side of porous electrode 6c of the Vs cel 6 for detection of internal resistance RVS in this example, and having passed the current to hard flow in iCP Since the internal polarization condition of the Vs cel 6 of having changed can be restored, the lock out space by the side of porous electrode 6c can be promptly operated as a source of internal reference oxygen, and the Vs cel 6 can be promptly operated as an oxygen density measurement cel. Therefore, it becomes possible to detect the internal resistance RVS of the Vs cel 6 with high precision, without being able to make time amount T four until it starts actuation of density measurement into time amount very short like 500microsec. after the processing starting concerned, and affecting measurement of an oxygen density and NOx concentration.

[0117] As explained above, it sets to the oxygen density and nitrogen-oxides density measurement equipment of this example. So that the temperature of the NOx sensor 2 may be detected from the internal resistance RVS of the Vs cel 6 which detects the oxygen density of the 1st test chamber 20 and this temperature may turn into target temperature (for example, 850 degrees C) Control the amount of energization currents to heaters 12 and 14, and moreover, when the chip temperature obtained from the detected internal resistance RVS or this internal resistance RVS separates from desired value It is made to carry out temperature compensation of the measurement result of NOx concentration and an oxygen density by amending the 2nd pump current IP 2 which expresses the measurement result of NOx concentration and an oxygen density with the amount of temperature compensation according to the deflection, and the 1st pump current IP 1, respectively. For this reason, according to the oxygen density and nitrogen-oxides density measurement equipment of this example, an oxygen density and NOx concentration can be detected with high precision, without being influenced by the temperature of the NOx sensor 2.

[0118] Moreover, especially, by this example, while the laminating of the NOx sensor 2 is carried out to the order of the 1st pump cel 4, the Vs cel 6, and the 2nd pump cel 8 When the laminating of the heaters 12 and 14 is carried out to the direction both sides of a laminating and the NOx sensor 2 is moreover projected [the] from a laminating 4d of diffusion limitation layers and the diffusion limitation layers 6d and 22d lap, and the heater wiring 12b and 14b of heaters 12 and 14 is arranged so that each [these] diffusion limitation layer may be pinched in an abbreviation center position. Therefore, in this example, the measured gas which can heat each cels 4-8 efficiently using heaters 12 and 14, and flows in the 1st test chamber 20 and the 2nd test chamber 26 through each diffusion limitation layer according to the structure of such an NOx sensor 2 can also be efficiently heated now. For this reason, according to this example, by controlling the temperature of the Vs cel 6, it becomes possible to control more certainly the temperature of each cel which constitutes the NOx sensor 2 to target temperature, and it can improve the accuracy of measurement of an oxygen density and NOx concentration.

[0119] In addition, if a sample and hold circuit is established in the input stage to the differential amplifier AMP and it is made to carry out sample hold of the porous electrode 6c side electrical potential difference Vs before measurement initiation of a chip temperature for example, the differential amplifier AMP will be operated with the electrical-potential-difference value which carried out sample hold, and current control of the 1st pump cel 4 can be made to maintain also during measurement of a chip temperature during measurement of a chip temperature, in this example, although it was made to suspend the current control to the 1st pump cel 4.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is an outline block diagram showing the configuration of the whole oxygen density and nitrogen-oxides density measurement equipment of an example.
[Drawing 2] It is a decomposition perspective view showing the configuration of the NOx sensor of an example.
[Drawing 3] It is a flow chart showing the oxygen density and NOx density measurement processing repeatedly performed in ECU of an example.
[Drawing 4] It is a flow chart showing the internal resistance detection processing performed as interrupt processing for every predetermined time in ECU of an example.
[Drawing 5] It is a graph showing the relation between the internal resistance of an oxygen density measurement cel, and a chip temperature.
[Drawing 6] It is a graph showing relation with the oxygen density of measured gas, the 1st pump current, and the 2nd pump current which do not contain NOx.
[Drawing 7] It is a timing diagram showing change of the 1st pump current produced by the exhaust air temperature change at the time of ** and moderation of an internal combustion engine, and the 2nd pump current.
[Drawing 8] It is a graph showing an example of the map used in case the amount of temperature compensation to the 2nd pump current is calculated.
[Drawing 9] It is a timing diagram explaining actuation of the internal resistance detection processing shown in drawing 4 .
[Drawing 10] It is an explanatory view explaining the temperature characteristic of the oxygen density which all field air-fuel ratio sensors set, and is obtained by pump current control.
[Description of Notations]
2 -- NOx sensor 4 -- The 1st pump cel 6 -- Vs cel
8 -- The 2nd pump cel 12 14 -- Heater
4a, 6a, 8a, 18, 22, 24 -- Solid electrolyte layer
4b, 4c, 6b, 6c, 8b, 8c -- Porous electrode
4d, 6d, 22d -- Diffusion limitation layer 6f -- Exsorption resistance section
12a, 14a -- Heater substrate 12b, 14b -- Heater wiring
20 -- The 1st test chamber 26 -- The 2nd test chamber 40 -- Drive circuit
40a -- Control section 40b, 40c -- Current regulator circuit 42 -- Detector
44 -- Heater energization circuit AMP -- Differential amplifier
R0, R1, R2, R3 -- Resistor
SW1, SW2, SW3 -- Open/close switch

[Translation done.]

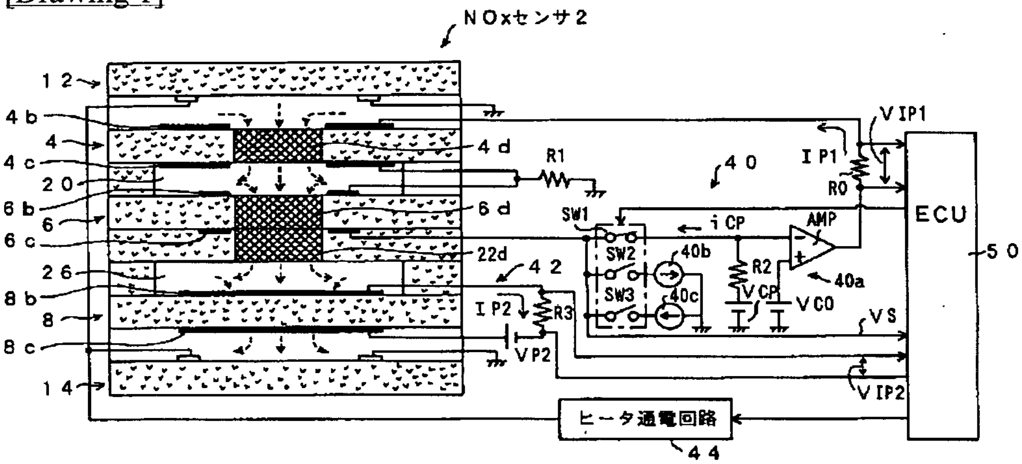
* NOTICES *

JPO and INPIT are not responsible for any
damages caused by the use of this translation.

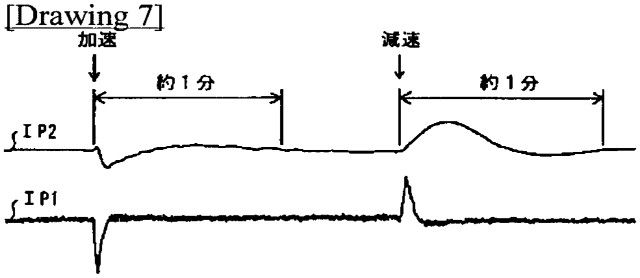
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

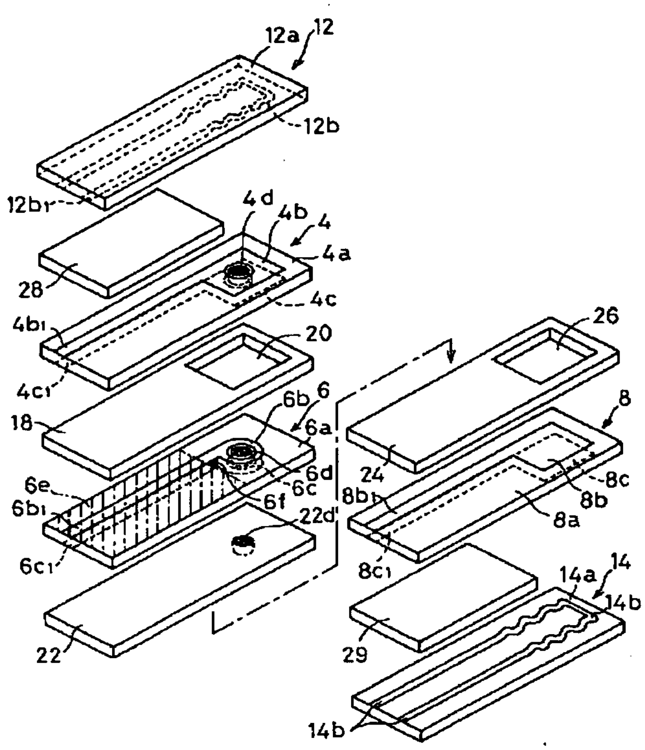
[Drawing 1]



[Drawing 7]

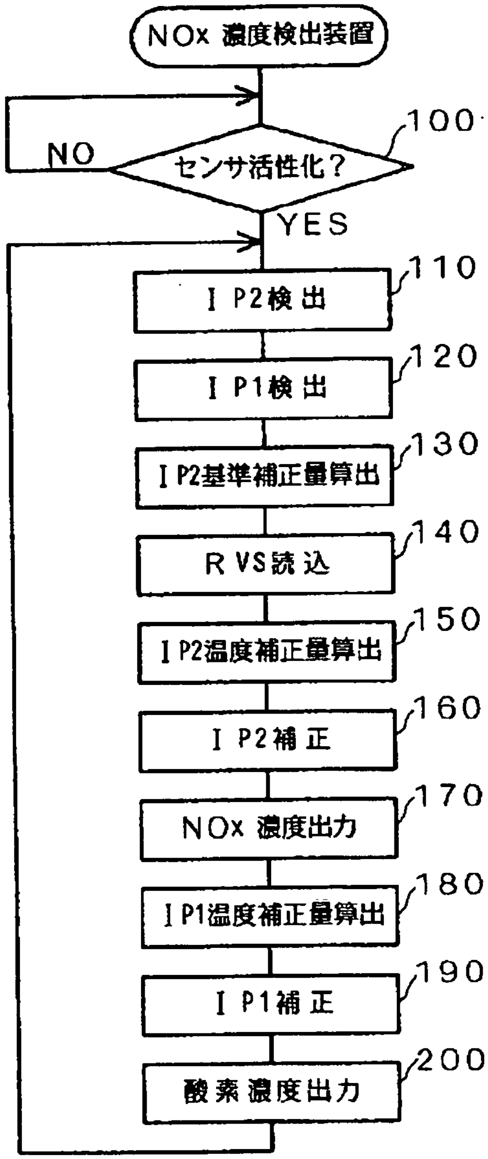


[Drawing 2]

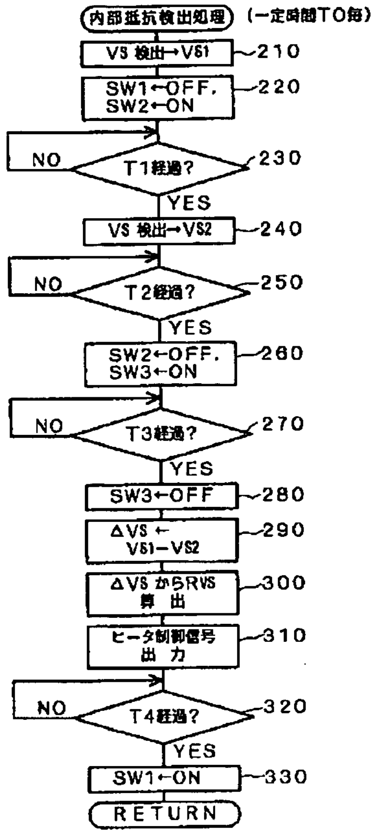


12a
12
12b
12b1
4d
4b
4
4a
28
4c
4b1
20
26
4c1
6b
6
8
18
6a
6e
6d
6c
24
8c
6b1
6f
22d'
8b1
8b
8a
6c1
8c1
14a
14
14b
22
29
14b

[Drawing 3]


NOx 濃度検出装置
100
センサ活性化？
NO
YES
110
I P2検出
120
I P1検出
130
I P2基準補正量算出
140
R VS読込
150
I P2温度補正量算出
160
I P2補正
170
NOx 濃度出力
180
I P1温度補正量算出
190
I P1補正
200
酸素濃度出力

[Drawing 4]



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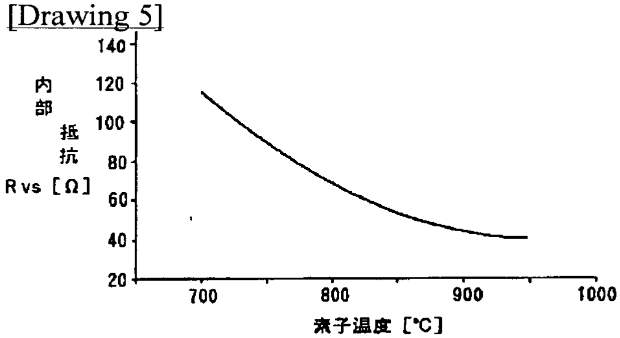

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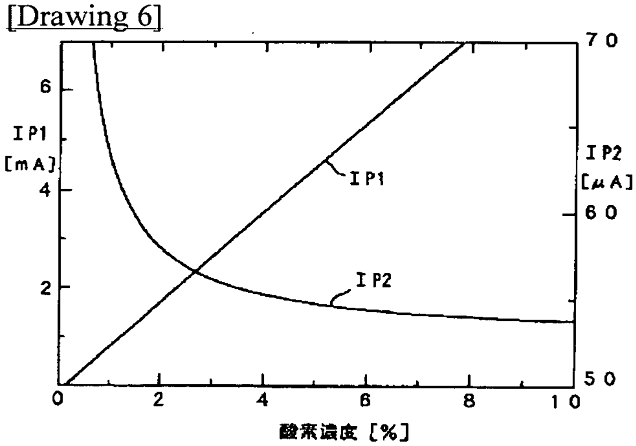
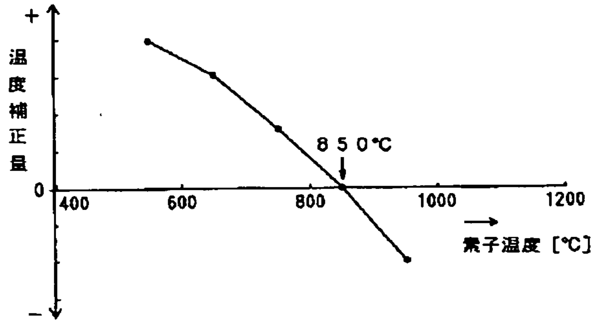
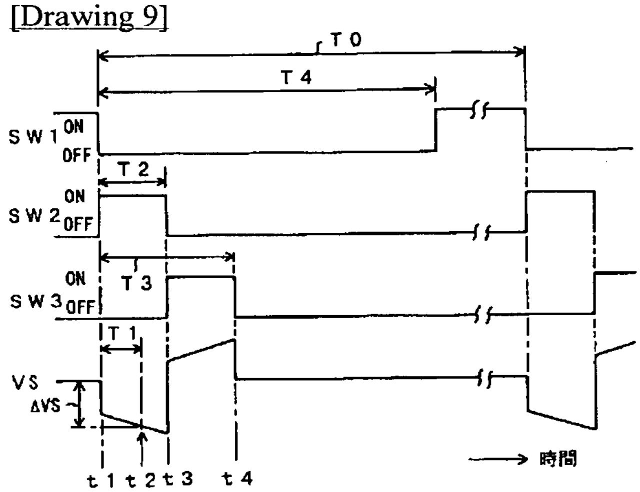


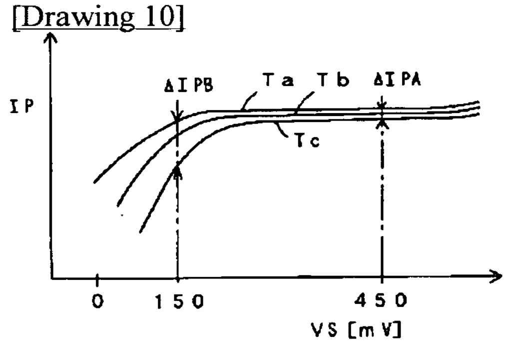
[Drawing 8]



[Drawing 9]



[Drawing 10]



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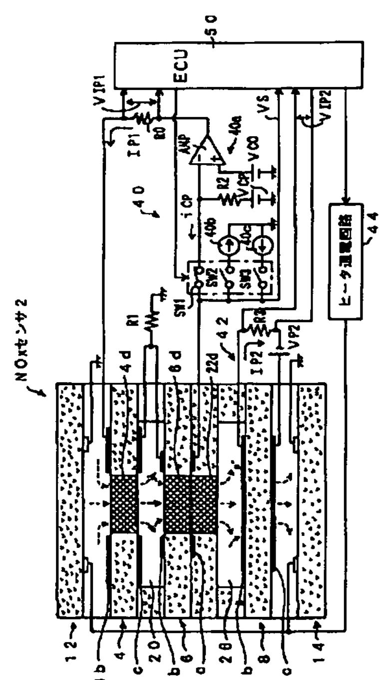
(54)【発明の名称】　酸素濃度・窒素酸化物濃度測定方法及び装置

(57)【要約】

【課題】　ＮＯｘセンサ１個でＮＯｘ濃度と酸素濃度とを正確に測定する。

【解決手段】　拡散律速層４ｄを介して被測定ガス側に連通した第１測定室２０と、拡散制限層６ｄ，２２ｄを介して第１測定室２０と連通した第２測定室２６からなり、第１測定室２０には第１ポンプセル４とＶｓセル６とが形成され、第２測定室２６には第２ポンプセル８が形成されたＮＯｘセンサ２を用いて、酸素濃度及びＮＯｘ濃度を測定する装置であって、Ｖｓセル６の出力が基準電圧VC0となるように第１ポンプ電流ＩP1を制御することにより、第１測定室２０内を一定の低酸素濃度に制御すると共に、第２ポンプセル８に定電圧を印加して第２測定室２６内のＮＯｘ成分を分解させて酸素を汲み出すことにより、第２ポンプ電流ＩP2からＮＯｘ濃度を、第１ポンプ電流ＩP1から酸素濃度を、夫々測定する。またこの測定時には、Ｖｓセルの内部抵抗からセンサ温度を検出して、ヒータ１２，１４の通電電流量を制御することにより、センサ温度を一定に保つ。



【特許請求の範囲】

【請求項１】　酸素イオン伝導性の固体電解質層を多孔質の電極で挟んでなる第１酸素ポンピングセル及び酸素濃度測定セルを有し、第１拡散律速層を介して被測定ガス側に連通された第１測定室と、酸素イオン伝導性の固体電解質層を多孔質の電極で挟んでなる第２酸素ポンピングセルを有し、第２拡散律速層を介して前記第１測定室と連通された第２測定室とを備えると共に、前記各セルを所定の活性温度まで加熱するヒータを備えたＮＯｘセンサを用いて、被測定ガス中の酸素濃度と窒素酸化物濃度とを測定する測定方法であって、
前記酸素濃度測定セルの出力電圧が一定値となるように前記第１酸素ポンピングセルに電流を流して、前記第１測定室内の酸素濃度を一定に制御すると共に、前記第２酸素ポンピングセルに前記第２測定室から酸素を汲み出す方向に一定電圧を印加することにより、
前記第２酸素ポンピングセルに流れる電流値から被測定ガス中の窒素酸化物濃度を測定し、前記第１酸素ポンピングセルに流れる電流値から被測定ガス中の酸素濃度を測定することを特徴とする酸素濃度・窒素酸化物濃度測定方法。

【請求項２】　請求項１に記載の測定方法において、前記ＮＯｘセンサにおける酸素濃度測定セルの温度が所定の目標温度となるように、前記ヒータへの通電を制御することを特徴とする酸素濃度・窒素酸化物濃度測定方法。

【請求項３】　請求項２に記載の測定方法において、前記酸素濃度測定セルの温度の前記目標温度からのずれに応じて、前記酸素濃度及び前記窒素酸化物濃度の測定結果を補正することにより、各測定結果を温度補償することを特徴とする酸素濃度・窒素酸化物濃度測定方法。

【請求項４】　酸素イオン伝導性の固体電解質層を多孔質の電極で挟んでなる第１酸素ポンピングセル及び酸素濃度測定セルを有し、第１拡散律速層を介して被測定ガス側に連通された第１測定室と、酸素イオン伝導性の固体電解質層を多孔質の電極で挟んでなる第２酸素ポンピングセルを有し、第２拡散律速層を介して前記第１測定室と連通された第２測定室とを備えると共に、前記各セルを所定の活性温度まで加熱するヒータを備えたＮＯｘセンサを用いて、被測定ガス中の酸素濃度と窒素酸化物濃度とを測定する測定装置であって、
前記酸素濃度測定セルの出力電圧が一定値となるように前記第１酸素ポンピングセルに電流を流して、前記第１測定室内の酸素濃度を一定に制御するポンプ電流制御手段と、
前記第２酸素ポンピングセルに前記第２測定室から酸素を汲み出す方向に一定電圧を印加する定電圧印加手段と、
前記第２酸素ポンピングセルに流れる電流値に基づき被測定ガス中の窒素酸化物濃度を測定する窒素酸化物濃度測定手段と、
前記第１酸素ポンピングセルに流れる電流値から被測定ガス中の酸素濃度を測定する酸素濃度測定手段と、
を備えたことを特徴とする酸素濃度・窒素酸化物濃度測定装置。

【請求項５】　前記酸素濃度測定セルの温度を検出する温度検出手段と、
該温度検出手段にて検出された前記酸素濃度測定セルの温度が所定の目標温度となるように、前記ヒータへの通電を制御するヒータ通電制御手段と、
を設けたことを特徴とする請求項４記載の酸素濃度・窒素酸化物測定装置。

【請求項６】　前記温度検出手段にて検出された前記酸素濃度測定セルの温度の前記目標温度からのずれに応じて、前記酸素濃度及び前記窒素酸化物濃度の測定結果を補正することにより各測定結果を温度補償する補正手段、を設けたことを特徴とする請求項５記載の酸素濃度・窒素酸化物濃度測定装置。

【請求項７】　前記温度検出手段は、前記酸素濃度測定セルの内部抵抗を検出することにより該セルの温度を検出し、前記ヒータ通電制御手段は、該検出された酸素濃度測定セルの内部抵抗が前記目標温度に対応した所定値となるように、前記ヒータへの通電を制御することを特徴とする請求項５又は請求項６記載の酸素濃度・窒素酸化物濃度測定装置。

【請求項８】　前記ＮＯｘセンサにおいて、前記酸素濃度測定セルの前記第１測定室とは反対側の多孔質電極は閉塞されると共に、該閉塞空間内の酸素の一部を漏出抵抗部を介して外部に漏出可能に形成されており、
前記ポンプ電流制御手段は、前記酸素濃度測定セルに前記第１測定室中の酸素を前記閉塞空間に汲み出す方向に微小電流を流して、該閉塞空間を内部酸素基準源として機能させつつ、該酸素濃度測定セルに生じる起電力が一定値となるように前記第１酸素ポンピングセルに流れる電流量を制御し、
前記温度検出手段は、前記ポンプ電流制御手段と前記酸素濃度測定セルとの接続を周期的に遮断して、該遮断時に、前記酸素濃度測定セルに、前記微小電流よりも大きな内部抵抗検出用電流を前記微小電流とは逆方向に流し、そのとき前記酸素濃度測定セルの電極間に生じる電圧から前記酸素濃度測定セルの内部抵抗を検出することを特徴とする請求項７記載の酸素濃度・窒素酸化物濃度測定装置。

【請求項９】　前記温度検出手段は、前記酸素濃度測定セルに前記内部抵抗検出用電流を流して内部抵抗を検出した後、該内部抵抗検出用電流とは逆方向に電流を流すことを特徴とする請求項８記載の酸素濃度・窒素酸化物濃度測定装置。

【請求項１０】　前記ＮＯｘセンサにおいて、前記第１酸素ポンピングセル，酸素濃度測定セル及び第２酸素ポ

ンピングセルは、夫々、互いに異なる薄板状の固体電解質層に形成され、前記第１測定室及び第２測定室は、該各固体電解質層を、前記第１及び第２酸素ポンピングセルを形成した固体電解質層を外側にして、所定の間隙を介して積層することにより構成され、

前記ヒータは、基板にヒータ配線を形成した薄板状の２枚のヒータ基板からなり、各ヒータ基板を前記ＮＯｘセンサにおける各固体電解質層の積層方向両側に所定の間隙を介して夫々配置することにより、前記ＮＯｘセンサを加熱可能に構成され、

しかも、前記第１拡散層を、前記第１酸素ポンピングセルが形成された固体電解質層の、前記ヒータ基板に形成されたヒータ配線の中央部との対向位置に形成してなることを特徴とする請求項４～請求項９いずれか記載の酸素濃度・窒素酸化物濃度測定装置。

【請求項１１】　前記第２拡散律速層を、前記ＮＯｘセンサを前記各固体電解質層の積層方向から投影したときに前記第１拡散律速層の少なくとも一部と重なるように形成し、該第２拡散律速層近傍に、前記酸素濃度測定セルを配置してなることを特徴とする請求項１０記載の酸素濃度・窒素酸化物濃度測定装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、内燃機関等の各種燃焼機器から排出される有害性分である窒素酸化物の濃度を検出するために構成されたＮＯｘセンサを用いて酸素濃度と窒素酸化物濃度とを測定する酸素濃度・窒素酸化物濃度測定方法及び装置に関する。

【０００２】

【従来の技術】従来より、窒素酸化物濃度測定装置として、例えば、ヨーロッパ特許出願公開明細書０６７８７４０Ａ１，ＳＡＥ　ｐａｐｅｒ　Ｎｏ．９６０３３４　Ｐ１３７～１４２　１９９６等に開示されているように、第１拡散律速層を介して被測定ガス側に連通された第１測定室と、この第１測定室に第２拡散律速層を介して連通された第２測定室とを、酸素イオン伝導性の固体電解質層にて形成し、第１測定室には、固体電解質層を多孔質の電極で挟むことにより第１酸素ポンピングセルと酸素濃度測定セルとを形成し、更に、第２測定室には、同じく固体電解質層を多孔質の電極で挟むことにより第２酸素ポンピングセルを形成したＮＯｘセンサを用いて、内燃機関等の排気中の窒素酸化物（ＮＯｘ）の濃度を検出するようにしたものが知られている。

【０００３】この種の窒素酸化物濃度測定装置においては、酸素濃度測定セルからの出力電圧が予め設定された一定値となるように第１酸素ポンピングセルに電流を流すことにより、第１測定室内の酸素濃度を一定濃度に制御しつつ、第２酸素ポンピングセルに一定電圧を印加して、第２測定室から酸素を汲み出す。そして、この第２酸素ポンピングセルに流れる電流値から、被測定ガス中のＮＯｘ濃度を検出する。

【０００４】つまり、被測定ガスである内燃機関等からの排気中には、ＮＯｘ以外に、酸素、一酸化炭素、二酸化炭素等の他のガス成分が存在するが、上記窒素酸化物濃度測定装置では、第１酸素ポンピングセルにより第１測定室内を酸素が極めて少ない低酸素濃度に制御し、更に、その低酸素濃度に制御された被測定ガスが流入する第２測定室側で、第２酸素ポンピングセルに第２測定室内の酸素を汲み出す方向に一定電圧を印加することにより、第２酸素ポンピングセルを構成する多孔質電極の触媒機能によって、被測定ガス中のＮＯｘを窒素と酸素とに分解させて第２測定室から酸素を抜き取り、そのとき第２酸素ポンピングセルに流れるポンプ電流を検出することにより、被測定ガス中の他のガス成分に影響されることなく、被測定ガス中のＮＯｘ濃度を検出できるようにしている。

【０００５】また、この種の窒素酸化物測定装置では、上記検出方法によってＮＯｘ濃度を正確に検出するには、センサを所定の活性温度（例えば８００℃以上）まで加熱して、各セルを活性化させる必要があることから、センサを加熱するためのヒータが別途設けられている。

【０００６】

【発明が解決しようとする課題】ところで、上記窒素酸化物濃度測定装置は、例えば、燃料に対する空気の量が多い希薄空燃比（リーン空燃比）で運転されて排気中のＮＯｘ成分が多くなる内燃機関（所謂リーンバーンエンジン）において、ＮＯｘの排出を抑制するためにＮＯｘを還元するＮＯｘ触媒の状態を監視することに使用される。

【０００７】つまり、内燃機関の排気通路のＮＯｘ触媒の下流側にＮＯｘセンサを装着してＮＯｘ濃度を測定することにより、ＮＯｘ触媒からのＮＯｘの漏出量を検出し、そのＮＯｘの漏出量が増えてきたところで、内燃機関に供給する燃料混合気の空燃比を、一時的に、燃料の多いリッチ空燃比に制御して、内燃機関から未燃ガスを排出させ、この未燃ガスとＮＯｘ触媒に蓄積されたＮＯｘとを反応させることにより、ＮＯｘの排出量を抑制する、といった制御に使用される。

【０００８】そして、このようなＮＯｘ制御を実現するには、上記窒素酸化物濃度測定装置では内燃機関に供給された燃料混合気の空燃比を測定することができないことから、内燃機関には、排気中の酸素濃度から空燃比を測定する空燃比測定装置を別途設ける必要がある。

【０００９】つまり、上記のようなＮＯｘ制御を行なう場合には、内燃機関において一般に行なわれている空燃比制御を併せて実行する必要があり、このためには、内燃機関の排気系に、ＮＯｘセンサと酸素濃度センサ（所謂空燃比センサ）とを夫々設けなければならない。

【００１０】そこで本発明は、このようにＮＯｘセンサ

と空燃比センサとの２つのセンサを用いることなく、ＮＯｘセンサだけで、ＮＯｘ濃度及び酸素濃度を測定し得る酸素濃度・窒素酸化物濃度測定方法及び装置を提供し、上記のようなＮＯｘ制御を実現するに当たってＮＯｘ濃度及び酸素濃度（空燃比）の検出系の構成を簡単にすることを目的とする。

【００１１】

【課題を解決するための手段】かかる目的を達成するためになされた請求項１に記載の発明は、酸素イオン伝導性の固体電解質層を多孔質の電極で挟んでなる第１酸素ポンピングセル及び酸素濃度測定セルを有し、第１拡散律速層を介して被測定ガス側に連通された第１測定室と、酸素イオン伝導性の固体電解質層を多孔質の電極で挟んでなる第２酸素ポンピングセルを有し、第２拡散律速層を介して前記第１測定室と連通された第２測定室とを備えると共に、前記各セルを所定の活性温度まで加熱するヒータを備えたＮＯｘセンサを用いて、被測定ガス中の酸素濃度と窒素酸化物濃度とを測定する測定方法であって、前記酸素濃度測定セルの出力電圧が一定値となるように前記第１酸素ポンピングセルに電流を流して、前記第１測定室内の酸素濃度を一定に制御すると共に、前記第２酸素ポンピングセルに前記第２測定室から酸素を汲み出す方向に一定電圧を印加することにより、前記第２酸素ポンピングセルに流れる電流値から被測定ガス中の窒素酸化物濃度を測定し、前記第１酸素ポンピングセルに流れる電流値から被測定ガス中の酸素濃度を測定することを特徴とする。

【００１２】そして、請求項２に記載の発明は、請求項１に記載の測定方法において、前記ＮＯｘセンサにおける酸素濃度測定セルの温度が所定の目標温度となるように、前記ヒータへの通電を制御することを特徴とする。また、請求項３に記載の発明は、請求項２に記載の測定方法において、前記酸素濃度測定セルの温度の前記目標温度からのずれに応じて、前記酸素濃度及び前記窒素酸化物濃度の測定結果を補正することにより、各測定結果を温度補償することを特徴とする。

【００１３】一方、請求項４に記載の発明は、請求項１に記載のＮＯｘセンサと同様のＮＯｘセンサを用いて、被測定ガス中の酸素濃度と窒素酸化物濃度とを測定する測定装置であって、前記酸素濃度測定セルの出力電圧が一定値となるように前記第１酸素ポンピングセルに電流を流して、前記第１測定室内の酸素濃度を一定に制御するポンプ電流制御手段と、前記第２酸素ポンピングセルに前記第２測定室から酸素を汲み出す方向に一定電圧を印加する定電圧印加手段と、前記第２酸素ポンピングセルに流れる電流値に基づき被測定ガス中の窒素酸化物濃度を測定する窒素酸化物濃度測定手段と、前記第１酸素ポンピングセルに流れる電流値から被測定ガス中の酸素濃度を測定する酸素濃度測定手段と、を備えたことを特徴とする。

【００１４】そして、請求項５に記載の発明は、この請求項４に記載の測定装置において、前記酸素濃度測定セルの温度を検出する温度検出手段と、該温度検出手段にて検出された前記酸素濃度測定セルの温度が所定の目標温度となるように、前記ヒータへの通電を制御するヒータ通電制御手段と、を設けたことを特徴とする。

【００１５】また、請求項６に記載の発明は、請求項５に記載の測定装置において、前記温度検出手段にて検出された前記酸素濃度測定セルの温度の前記目標温度からのずれに応じて、前記酸素濃度及び前記窒素酸化物濃度の測定結果を補正することにより各測定結果を温度補償する補正手段、を設けたことを特徴とする。

【００１６】また次に、請求項７に記載の発明は、請求項５又は請求項６記載の酸素濃度・窒素酸化物濃度測定装置において、前記温度検出手段は、前記酸素濃度測定セルの内部抵抗を検出することにより該セルの温度を検出し、前記ヒータ通電制御手段は、該検出された酸素濃度測定セルの内部抵抗が前記目標温度に対応した所定値となるように、前記ヒータへの通電を制御することを特徴とする。

【００１７】また、請求項８に記載の発明は、請求項７に記載の酸素濃度・窒素酸化物濃度測定装置において、前記ＮＯｘセンサにおいて、前記酸素濃度測定セルの前記第１測定室とは反対側の多孔質電極は閉塞されると共に、該閉塞空間内の酸素の一部を漏出抵抗部を介して外部に漏出可能に形成されており、前記ポンプ電流制御手段は、前記酸素濃度測定セルに前記第１測定室中の酸素を前記閉塞空間に汲み出す方向に微小電流を流して、該閉塞空間を内部酸素基準源として機能させつつ、該酸素濃度測定セルに生じる起電力が一定値となるように前記第１酸素ポンピングセルに流れる電流量を制御し、前記温度検出手段は、前記ポンプ電流制御手段と前記酸素濃度測定セルとの接続を周期的に遮断して、該遮断時に、前記酸素濃度測定セルに、前記微小電流よりも大きな内部抵抗検出用電流を前記微小電流とは逆方向に流し、そのとき前記酸素濃度測定セルの電極間に生じる電圧から前記酸素濃度測定セルの内部抵抗を検出することを特徴とする。

【００１８】また、請求項９に記載の発明は、請求項８記載の酸素濃度・窒素酸化物濃度測定装置において、前記温度検出手段は、前記酸素濃度測定セルに前記内部抵抗検出用電流を流して内部抵抗を検出した後、該内部抵抗検出用電流とは逆方向に電流を流すことを特徴とする。

【００１９】一方、請求項１０に記載の発明は、請求項４～請求項９いずれか記載の酸素濃度・窒素酸化物濃度測定装置において、前記ＮＯｘセンサにおいて、前記第１酸素ポンピングセル，酸素濃度測定セル及び第２酸素ポンピングセルは、夫々、互いに異なる薄板状の固体電解質層に形成され、前記第１測定室及び第２測定室は、

該各固体電解質層を、前記第１及び第２酸素ポンピングセルを形成した固体電解質層を外側にして、所定の間隙を介して積層することにより構成され、前記ヒータは、基板にヒータ配線を形成した薄板状の２枚のヒータ基板からなり、各ヒータ基板を前記ＮＯｘセンサにおける各固体電解質層の積層方向両側に所定の間隙を介して夫々配置することにより、前記ＮＯｘセンサを加熱可能に構成され、しかも、前記第１拡散層を、前記第１酸素ポンピングセルが形成された固体電解質層の、前記ヒータ基板に形成されたヒータ配線の中央部との対向位置に形成してなることを特徴とする。

【００２０】また、請求項１１に記載の発明は、請求項１０に記載の酸素濃度・窒素酸化物濃度測定装置において、前記第２拡散律速層を、前記ＮＯｘセンサを前記各固体電解質層の積層方向から投影したときに前記第１拡散律速層の少なくとも一部と重なるように形成し、該第２拡散律速層近傍に、前記酸素濃度測定セルを配置してなることを特徴とする。

【００２１】

【発明の実施の形態】請求項１に記載の測定方法では、ＮＯｘセンサにおける酸素濃度測定セルの出力電圧が一定値となるように第１酸素ポンピングセルに電流を流して、第１測定室内の酸素濃度を一定に制御すると共に、第２酸素ポンピングセルに第２測定室から酸素を汲み出す方向に一定電圧を印加する。つまり、本発明方法では、ＮＯｘセンサを用いてＮＯｘ濃度を測定する場合と同様の駆動方向でＮＯｘセンサを駆動する。そして、このとき第２酸素ポンピングセルに流れる電流値から被測定ガス中の窒素酸化物濃度（ＮＯｘ濃度）を測定するだけでなく、第１酸素ポンピングセルに流れる電流値から被測定ガス中の酸素濃度を測定する。

【００２２】これは、第１ポンピングセルに流れる電流を制御して第１測定室の酸素濃度を一定に制御するポンプ電流制御は、被測定ガスの拡散が制限された測定室にポンピングセルと酸素濃度測定セルとを設けた全領域空燃比センサを用いて被測定ガス中の酸素濃度を測定するときの動作と同じであり、第１ポンピングセルに流れるポンプ電流は、被測定ガス中の酸素濃度に比例し、その電流値から酸素濃度を測定できるからである。

【００２３】そしてこのように、本発明によれば、ＮＯｘセンサのみを用いて、被測定ガス中の酸素濃度とＮＯｘ濃度とを測定するため、前述した内燃機関のＮＯｘ制御を実現するために、内燃機関の排気系にＮＯｘセンサと空燃比センサとの２つのセンサを設ける必要がなく、その制御装置の構成を簡単にして、コストダウンを図ることができる。

【００２４】また、本発明によれば、一つのＮＯｘセンサを用いて酸素濃度とＮＯｘ濃度とを測定するため、これら各測定結果は、酸素濃度とＮＯｘ濃度とを異なるセンサ（つまり酸素センサとＮＯｘセンサ）を用いて測定した場合に比べて、極めて高い相関性を有することになる。従って、本発明方法により測定した酸素濃度とＮＯｘ濃度とを用いれば、内燃機関の排気管に設けたＮＯｘ触媒の劣化を高精度に判定することができるようになる。

【００２５】即ち、ＮＯｘ触媒の劣化を知るには、定常的にＮＯｘがどの程度漏出しているかを検出する必要があり、このためには、ＮＯｘの漏出量とそのときの制御空燃比とを比較し、制御空燃比に対するＮＯｘの漏出量が所定の許容範囲内にあるか否かを判定するようにすればよい。

【００２６】つまり、内燃機関において、供給した燃料混合気の空燃比が小さいときにはＮＯｘの漏出量は少なく、逆に空燃比が大きいときにはＮＯｘの漏出量は多くなることから、空燃比に対するＮＯｘ漏出量の許容値を予め設定しておき、内燃機関の運転時には、排気中の酸素濃度及びＮＯｘ濃度を同時に測定して、その測定した酸素濃度（換言すれば空燃比）に対応したＮＯｘ漏出量の許容値を読み出し、測定したＮＯｘ濃度がその許容値以下であるか否かを判断して、ＮＯｘ濃度が許容値を越えている場合に、ＮＯｘ触媒の劣化を判定するようにすれば、排気中の酸素濃度とＮＯｘ濃度とからＮＯｘ触媒の劣化を判定することができる。

【００２７】そして、このようなＮＯｘ触媒の劣化判定を行う場合、酸素濃度の測定とＮＯｘ濃度の測定とに異なるセンサを用いるようにしていると、各センサ毎の特性のばらつきや劣化の程度の差等によって、空燃比に対するＮＯｘ濃度の検出特性に誤差が生じ、ＮＯｘ触媒の劣化の判定精度が低下することが考えられる。

【００２８】しかし、個々のＮＯｘセンサ自体に特性のばらつきがあったとしても、１個のＮＯｘセンサによる空燃比とＮＯｘの検出精度のばらつきの差はない。そして、本発明によれば、一つのＮＯｘセンサを用いて被測定ガス中の酸素濃度とＮＯｘ濃度とを測定することから、空燃比に対するＮＯｘ濃度の検出特性に誤差が生じることはなく、その測定結果から、ＮＯｘ触媒の劣化を高精度に判定することができるようになるのである。

【００２９】次に請求項２に記載の測定方法では、ＮＯｘセンサにおける酸素濃度測定セルの温度が所定の目標温度となるように、ＮＯｘセンサに設けられたヒータへの通電を制御する。これは、第１酸素ポンピングセルへの通電制御（ポンプ電流制御）によって第１測定室の酸素濃度を一定に制御できなければ、酸素濃度もＮＯｘ濃度も正確に測定することはできず、第１測定室の酸素濃度を一定に制御するには、その酸素濃度を測定する酸素濃度測定セルの温度を一定温度に保持する必要があるためである。

【００３０】つまり、酸素濃度測定セルは、固体電解質層を一対の多孔質電極で挟んだ場合、その電極間に、各電極側の酸素分圧Ｐ１，Ｐ２に応じて、ネルンストの式

(1)

ＥＭＦ＝ａ×Ｔ×ｌｏｇ（Ｐ１／Ｐ２）　…(1)

但し、ａ：比例定数、Ｔは絶対温度

で得られる起電力ＥＭＦが生じることを利用し、酸素濃度測定室の第１測定室とは反対側の多孔質電極側を基準酸素濃度（酸素分圧Ｐ１）とすることにより、第１測定室内の酸素濃度を測定するものである。従って、例えば、酸素濃度測定セルの温度Ｔが１０００°Ｋで、第１測定室内の酸素濃度が１０００ｐｐｍであったときに、酸素濃度測定セルの起電力ＥＭＦが２００ｍＶであったとすれば、温度Ｔが８００°Ｋになると、起電力ＥＭＦは１６０ｍＶとなってしまう。このため、第１測定室の酸素濃度を一定に制御するには（換言すれば、酸素濃度及びＮＯｘ濃度を正確に測定するには）、酸素濃度測定セルの温度を一定温度に保持する必要がある。

【００３１】特に、従来より酸素濃度の測定に使用されている前述の全領域空燃比センサにおいては、ポンプ電流制御により測定室内を酸素が殆ど存在しない状態（酸素濃度ゼロの状態）に制御していることから、比較的安定した温度特性を得ることができるが、ＮＯｘセンサでは、ポンプ電流制御により第１測定室内を酸素濃度ゼロの状態に制御すると、第１測定室内に流入した被測定ガス中のＮＯｘ成分を分解してしまい、第２酸素ポンピングセルを用いてＮＯｘ濃度を測定できない虞があるので、通常、第１測定室内の酸素濃度を、酸素が少し残った状態（例えば１０００ｐｐｍ程度の低酸素濃度）に制御しており、この結果、全領域空燃比センサに比べて温度特性が著しく低下する。

【００３２】例えば、図１０は、従来の全領域空燃比センサを用いたポンプ電流制御によって被測定ガス（酸素濃度固定）の酸素濃度を測定した場合の酸素濃度測定セルの出力電圧Ｖｓと酸素ポンピングセルに流れるポンプ電流Ｉｐとの関係を表しているが、この図から明らかなように、酸素濃度測定セルの出力電圧Ｖｓが４５０ｍＶとなって、測定室内の酸素濃度が略ゼロ（理論的には１$0^{-9}$ atm 程度）となるように、ポンプ電流Ｉｐを制御した場合には、酸素濃度測定セルの温度をＴａ，Ｔｂ，Ｔｃと変化させても、ポンプ電流Ｉｐは△ＩPAしか変化せず、一度当たりの電流変化率は２％程度であるが、酸素濃度測定セルの出力電圧Ｖｓが１５０ｍＶとなって、測定室内の酸素濃度が１０００ｐｐｍ程度の低酸素濃度となるように、ポンプ電流Ｉｐを制御した場合には、酸素濃度測定セルの温度をＴａ，Ｔｂ，Ｔｃと変化させると、ポンプ電流Ｉｐは△ＩPBと大きく変化し、一度当たりの電流変化率は数十％になってしまう。

【００３３】従って、本発明のようにＮＯｘセンサを利用して酸素濃度及びＮＯｘ濃度を正確に測定するに当たって、第１酸素ポンピングセルのポンプ電流制御によって第１測定室内の酸素濃度を１０００ｐｐｍ程度の低酸素濃度に制御する場合には、酸素濃度測定セルの温度を、一定温度に、より正確に制御する必要がある。

【００３４】これに対して、請求項２に記載の測定方法によれば、ＮＯｘセンサにおける酸素濃度測定セルの温度が所定の目標温度となるようにヒータへの通電を制御するため、酸素濃度測定セルを一定の目標温度に保持することができる。従って、請求項２に記載の測定方法によれば、ＮＯｘセンサを用いて酸素濃度とＮＯｘ濃度とを測定することができるだけでなく、その測定精度を向上することができ、上述した内燃機関のＮＯｘ制御やＮＯｘ触媒の劣化判定を、より高精度に行うことが可能になる。

【００３５】また次に、請求項３に記載の測定方法では、更に、酸素濃度測定セルの温度の目標温度からのずれに応じて、酸素濃度及び窒素酸化物濃度の測定結果を補正する。このため、本発明方法によれば、ヒータへの通電制御によって酸素濃度測定セルの温度を制御しているにもかかわらず、その温度が目標温度から変化してしまったとしても、酸素濃度及びＮＯｘ濃度の測定結果を温度補償することができ、酸素濃度及びＮＯｘ濃度をより高精度に測定することができる。

【００３６】つまり、例えば、内燃機関の運転状態が変化して、被測定ガスである排気の温度が急変したような場合には、被測定ガスの温度変化に応じてＮＯｘセンサの温度が一時的に変化し、ヒータ制御によって酸素濃度測定セルの温度を制御しきれないことがある。しかし、請求項３に記載の測定方法によれば、このような場合にも、酸素濃度及びＮＯｘ濃度を正確に測定できる。

【００３７】次に、請求項４に記載の測定装置は、上記請求項１に記載の測定方法を実現する装置である。そして、この装置では、まず、ポンプ電流制御手段が、酸素濃度測定セルの出力電圧が一定値となるように第１酸素ポンピングセルに電流を流して、第１測定室内の酸素濃度を一定に制御すると共に、定電圧印加手段が、第２酸素ポンピングセルに第２測定室から酸素を汲み出す方向に一定電圧を印加する。そして、窒素酸化物濃度測定手段が、第２酸素ポンピングセルに流れる電流値に基づき被測定ガス中の窒素酸化物濃度を測定し、酸素濃度測定手段が、第１酸素ポンピングセルに流れる電流値から被測定ガス中の酸素濃度を測定する。

【００３８】従って、請求項４に記載の測定装置によれば、上記請求項１に記載の測定方法を実現して、一つのＮＯｘセンサを用いて被測定ガス中の酸素濃度とＮＯｘ濃度とを測定することができるようになり、前述した内燃機関のＮＯｘ制御を行う制御装置の構成を簡単にして、その装置のコストダウンを図ることができると共に、前述したＮＯｘ触媒の劣化判定を正確に行うことができるようになる。

【００３９】また次に、請求項５に記載の測定装置では、更に、温度検出手段が、酸素濃度測定セルの温度を検出し、ヒータ通電制御手段が、その検出した酸素濃度

測定セルの温度が所定の目標温度となるように、ＮＯｘセンサに設けられたヒータへの通電を制御する。つまり、請求項５に記載の測定装置は、請求項２に記載の測定方法を実現する装置であり、ＮＯｘセンサを用いて酸素濃度とＮＯｘ濃度とを測定できるだけでなく、その測定精度を向上して、内燃機関のＮＯｘ制御やＮＯｘ触媒の劣化判定をより正確に行うことが可能になる。

【００４０】また、請求項６に記載の測定装置においては、更に、補正手段が、温度検出手段にて検出された酸素濃度測定セルの温度の目標温度からのずれに応じて、酸素濃度及び前記窒素酸化物濃度の測定結果を補正する。つまり、請求項６に記載の測定装置は、請求項３に記載の測定方法を実現する装置であり、ヒータ通電制御手段によって酸素濃度測定セルの温度を目標温度に制御しているにもかかわらず、その温度が被測定ガス等の温度変化の影響を受けて目標温度から変化してしまった場合にでも、酸素濃度及びＮＯｘ濃度の測定結果を温度補償することができる。このため、酸素濃度及びＮＯｘ濃度をより高精度に測定することが可能になる。

【００４１】ここで、酸素濃度測定セルの温度を検出する温度検出手段としては、例えば、酸素濃度測定セル近傍に温度検出用の素子を設けることによって実現することもできるが、この場合、ＮＯｘセンサの構造が複雑になり、また酸素濃度測定セル自体の温度を正確に検出することも難しい。

【００４２】従って、請求項７に記載のように、温度検出手段を、酸素濃度測定セルの内部抵抗を検出するように構成し、ヒータ通電制御手段において、その検出された酸素濃度測定セルの内部抵抗が目標温度に対応した所定値となるように、ヒータへの通電を制御するようにすることが望ましい。

【００４３】つまり、酸素濃度測定セルの内部抵抗は、酸素濃度測定セルの温度に応じて変化する（温度が高くなる程内部抵抗が低くなる）ことから、請求項７に記載のように、酸素濃度測定セルの内部抵抗を検出するようにすれば、その検出した内部抵抗から、ＮＯｘセンサに温度検出用の素子を別途設けることなく、酸素濃度測定セルの温度を正確に検出することができるようになり、ＮＯｘセンサ（詳しくは酸素濃度測定セル）の温度制御を、より簡単且つ高精度に実行できることになる。

【００４４】またこのように、温度検出手段にて酸素濃度測定セルの内部抵抗を検出する場合、温度検出手段としては、例えば、酸素濃度測定セルに内部抵抗検出用の定電圧を印加し、そのとき酸素濃度測定セルに流れる電流量を検出するように構成するか、或いは酸素濃度測定セルに内部抵抗検出用の定電流を流し、そのとき酸素濃度測定セルの両端電圧を検出するように構成すればよい。

【００４５】但し、このように酸素濃度測定セルの内部抵抗を検出する際には、一時的に、ポンプ電流制御手段と酸素濃度測定セルとの接続を遮断して、ポンプ電流制御手段による第１酸素ポンピングセルの通電制御を停止させる必要はある。つまり、内部抵抗検出のために酸素濃度測定セルに通電すると、その両端電圧は、第１測定室内の酸素濃度とは対応しない値となり、そのときポンプ電流制御手段の制御動作を継続させると、第１測定室内の酸素濃度が誤制御されてしまうことから、酸素濃度測定セルの内部抵抗検出時には、こうした誤制御が生じることのないよう、ポンプ電流制御手段による制御動作を停止させることが望ましい。

【００４６】また次に、酸素濃度測定セルは、前述の(1)式で得られる起電力ＥＭＦにより第１測定室内の酸素濃度を測定するものであり、このセルを構成する一対の多孔質電極のうち、第１測定室と接しない電極側の酸素濃度は、一定の基準酸素濃度にする必要がある。そして、このためには、例えば、その電極側に、酸素濃度が一定の基準ガス（例えば大気）を導入するようにしてもよいが、このように外部から基準ガスを導入するには、ＮＯｘセンサに基準ガス導入のための空隙を設けなければならず、ＮＯｘセンサの構造が複雑になってしまう。

【００４７】そこで、酸素濃度測定セルの第１測定室とは反対側の多孔質電極を基準酸素濃度とするには、請求項８に記載のように、ＮＯｘセンサにおいて、酸素濃度測定セルの第１測定室とは反対側の多孔質電極を閉塞すると共に、その閉塞空間内の酸素の一部が漏出抵抗部を介して外部に漏出可能に形成し、ポンプ電流制御手段側で、酸素濃度測定セルに対して、第１測定室中の酸素を閉塞空間に汲み出す方向に微小電流を流し、その閉塞空間を内部酸素基準源として機能させつつ、酸素濃度測定セルに生じる起電力が一定値となるように第１酸素ポンピングセルに流れる電流量を制御するようにすればよい。つまり、このように構成すれば、ＮＯｘセンサに基準ガス導入のための空隙を設ける必要はなく、ＮＯｘセンサの構造を簡単にすることができる。

【００４８】そして、この場合、温度検出手段により酸素濃度測定セルの内部抵抗を測定するには、請求項８に記載のように、温度検出手段を、ポンプ電流制御手段と酸素濃度測定セルとの接続を周期的に遮断して、その遮断時に、酸素濃度測定セルに、内部酸素基準源生成用の微小電流よりも大きな内部抵抗検出用電流を、微小電流とは逆方向に流し、そのとき酸素濃度測定セルの電極間に生じる電圧から、酸素濃度測定セルの内部抵抗を検出するようにすることが望ましい。

【００４９】即ち、本発明の酸素濃度測定セルは微小電流の通電により内部酸素基準源を自己生成するため、その内部酸素基準源となる閉塞空間内には酸素が充分蓄積されており、内部抵抗検出用の電流を微小電流と同方向に流すと閉塞空間内の酸素が多くなり過ぎ、充満した酸素によってＮＯｘセンサに亀裂が入る虞がある。

【００５０】そこで、請求項８に記載の測定装置では、

酸素濃度測定セルの内部抵抗を検出するために、酸素濃度測定セルに対して、通常時に流す微小電流とは逆方向に内部抵抗検出用の電流を流し、そのとき生じた電極間電圧から、酸素濃度測定セルの内部抵抗を検出するようにしているのである。

【００５１】なお、酸素濃度測定セルに電流を流した場合、酸素濃度測定セルが発生する電圧（電極間電圧）は、酸素濃度測定セルの内部抵抗だけでなく、各電極側の酸素濃度の比に応じて発生する起電力によっても変化するが、酸素濃度測定セルの各電極側の酸素濃度（つまり第１測定室内の酸素濃度及び閉塞空間内の酸素濃度）は、夫々、微小電流の通電及びポンプ電流制御手段による第１酸素ポンピングセルの通電制御によって、略一定になっているため、内部抵抗検出用電流の通電開始直後の起電力は程一定であり、本発明によれば、この起電力の影響を受けることなく酸素濃度測定セルの内部抵抗を検出できる。

【００５２】またこのように、酸素濃度測定セルの内部抵抗を検出するために、酸素濃度測定セルに内部抵抗検出用電流を流した場合、酸素濃度測定セルはポンピングセルとして働き、その通電電流量に応じて、電流方向とは逆方向に酸素が移動する。この結果、閉塞空間内の酸素濃度は、内部抵抗検出用電流とその通電時間とに応じて低下し、内部抵抗検出後、微小電流の通電によって閉塞空間内の酸素濃度が基準酸素濃度に戻り、酸素濃度測定セルにて第１測定室内の酸素濃度を正確に検出できるようになるには、ある程度の時間を要し、内部抵抗検出直後から、ポンプ電流制御手段の制御動作を再開させても、被測定ガス中の酸素濃度及びＮＯｘ濃度を正確に測定することはできない。

【００５３】そして、内部抵抗検出後、酸素濃度及びＮＯｘ濃度を正確に測定できるようになるまでの時間を短くにするには、請求項９に記載のように、温度検出手段を、酸素濃度測定セルに内部抵抗検出用電流を流して内部抵抗を検出した後、その内部抵抗検出用電流とは逆方向に電流を流すように構成すればよい。

【００５４】つまり、酸素濃度測定セルの内部抵抗検出時には、酸素濃度測定セルに、内部抵抗検出用電流を交番に流すようにすれば、酸素濃度測定セルの各電極側の酸素濃度，及び酸素濃度測定セルの一時的な起電力低下の状態が、内部抵抗検出前の安定状態に速やかに復帰することになり、内部抵抗検出後、酸素濃度及びＮＯｘ濃度を正確に測定できるようになるまでの時間を短くできる。

【００５５】また次に、本発明では、ＮＯｘセンサを構成している３種のセルのうち、酸素濃度及びＮＯｘ濃度の測定精度に最も影響を与える第１測定室内の酸素濃度を検出する酸素濃度測定セルの温度を検出して、その温度が目標温度となるようにヒータへの通電電流を制御するが、ＮＯｘセンサの構造によっては、第１酸素ポンピングセルや第２酸素ポンピングセルの温度が目標温度から大きくずれて、酸素濃度及びＮＯｘ濃度の測定精度を確保できないことも考えられる。

【００５６】そこで、ヒータ通電制御手段による効果をより良好に得られるようにするには、請求項１０に記載のように、ＮＯｘセンサにおいて、第１酸素ポンピングセル，酸素濃度測定セル及び第２酸素ポンピングセルは、夫々、互いに異なる薄板状の固体電解質層に形成され、第１測定室及び第２測定室は、各固体電解質層を、第１及び第２酸素ポンピングセルを形成した固体電解質層を外側にして、所定の間隙を介して積層することにより構成され、ヒータは、基板にヒータ配線を形成した薄板状の２枚のヒータ基板からなり、各ヒータ基板をＮＯｘセンサにおける各固体電解質層の積層方向両側に所定の間隙を介して夫々配置することにより、ＮＯｘセンサを加熱可能に構成され、しかも、第１拡散層を、第１酸素ポンピングセルが形成された固体電解質層の、ヒータ基板に形成されたヒータ配線の中央部との対向位置に形成することが望ましい。

【００５７】つまり、ＮＯｘセンサ及びヒータを上記のように形成すれば、酸素濃度測定セルが形成された固体電解質層が、第１酸素ポンピングセル及び第２酸素ポンピングセルが形成された固体電解質層に挟まれ、更にその積層方向両側にヒータ基板が配置されることになるので、ヒータの通電制御によって酸素濃度測定セルの温度を目標温度に制御すれば、第１酸素ポンピングセル及び第２酸素ポンピングセルをより確実に目標温度に制御することができ、しかも第１拡散層から第１測定室に流入する被測定ガスもヒータにより充分加熱することができるようになる。

【００５８】この結果、請求項１０に記載の測定装置によれば、ＮＯｘセンサにおける各セルの温度のばらつきを少なくすると共に、各セルが被測定ガスの温度の影響を受け難くして、酸素濃度及びＮＯｘ濃度の測定精度をより向上することが可能になる。

【００５９】またこの場合、請求項１１に記載のように、第２拡散律速層を、ＮＯｘセンサを各固体電解質層の積層方向から投影したときに第１拡散律速層の少なくとも一部と重なるように形成し、この第２拡散律速層近傍に、酸素濃度測定セルを配置するようにすれば、ＮＯｘセンサ及びその内部の被測定ガスの温度を目標温度により確実に制御することができ、酸素濃度及びＮＯｘ濃度の測定精度を向上できることになる。

【００６０】

【実施例】以下に本発明の一実施例を図面と共に説明する。図１は本発明が適用された実施例の酸素濃度・窒素酸化物濃度測定装置全体の構成を表す概略構成図、図２はこの測定装置において用いられるＮＯｘセンサ２の分解斜視図である。図１に示す如く、本実施例の測定装置は、ＮＯｘセンサ２と、ＮＯｘセンサ２を構成する第１

酸素ポンピングセル（以下、第１ポンプセルという）４及び酸素濃度測定セル（以下、Ｖｓセルという）６への通電及び通電経路の切り換えを行なうと共に、第１ポンプセル４に流れる電流（以下、第１ポンプ電流という）ＩP1を検出する駆動回路４０と、ＮＯｘセンサ２を構成する第２酸素ポンピングセル（以下、第２ポンプセルという）８に定電圧を印加してそのとき流れる電流（以下、第２ポンプ電流という）ＩP2を検出する検出回路４２と、ＮＯｘセンサ２に設けられた一対のヒータ１２，１４へ通電して各セル４，６，８を加熱させるヒータ通電回路４４と、駆動回路４０及びヒータ通電回路４４を制御すると共に、駆動回路４０及び検出回路４２からの検出信号ＶＩP1，ＶＩP2 に基づき被測定ガス中の酸素濃度及びＮＯｘ濃度を演算する、マイクロコンピュータからなる電子制御回路（以下、ＥＣＵという）５０とから構成されている。

【００６１】図２に示す如く、ＮＯｘセンサ２において、第１ポンプセル４は、板状に形成された固体電解質層４ａの両側に、夫々、矩形状の多孔質電極４ｂ，４ｃ及びそのリード部４bl，４clを形成し、更に、多孔質電極４ｂ，４ｃの中心部分を貫通するように固体電解質層４ａに丸孔を穿設して、その丸孔に多孔質の充填材を詰めることにより、拡散律速層４ｄを形成したものである。

【００６２】またＶｓセル６は、第１ポンプセル４の固体電解質層４ａと同形状の固体電解質層６ａの両側に、夫々、円形状の多孔質電極６ｂ，６ｃ及びそのリード部６bl，６clを形成し、更に、多孔質電極６ｂ，６ｃの中心部分を貫通するように固体電解質層６ａに丸孔を穿設して、その丸孔に多孔質の充填材を詰めることにより、拡散律速層６ｄを形成したものである。

【００６３】そして、このＶｓセル６の多孔質電極６ｂ，６ｃと第１ポンプセル４の多孔質電極４ｂ，４ｃとは、固体電解質層４ａ，６ａ上での中心位置が略一致し、Ｖｓセル６と第１ポンプセル４とを積層した際、各拡散律速層６ｄ，４ｄが互いに対向するようにされている。また、Ｖｓセル６に形成される円形状の多孔質電極６ｂ，６ｃは、第１ポンプセル４に形成される矩形状の多孔質電極４ｂ，４ｃよりも小さくなっている。また、Ｖｓセル６の表裏面には、リード部６bl，６clからの電流リークを防止するために、リード部６bl，６clを外側から覆うようにアルミナ等からなる絶縁膜が形成されており、しかも各リード部６bl，６cl間には、後述の通電制御によって多孔質電極６ｃ側に汲み込まれた酸素の一部を多孔質電極６ｂ側に漏出させる漏出抵抗部６ｆが形成されている。

【００６４】このように形成された第１ポンプセル４及びＶｓセル６は、上記各固体電解質層４ａ，６ａと同形状の固体電解質層１８を介して積層される。そして、この固体電解質層１８の各多孔質電極４ｃ，６ｂとの対向位置には、多孔質電極４ｃよりも大きな矩形状の孔が穿設されており、この孔が第１測定室２０として機能する。

【００６５】またＶｓセル６の多孔質電極６ｃ側にも、上記各固体電解質層４ａ，６ａと同形状の固体電解質層２２が積層される。そして、この固体電解質層２２には、Ｖｓセル６の拡散律速層６ｄと同位置に同寸法の丸孔を穿設して、その丸孔に多孔質の充填材を詰めることにより、拡散律速層２２ｄが形成されている。

【００６６】一方、第２ポンプセル８は、第１ポンプセル４と同様、板状に形成された固体電解質層８ａの両側に、夫々、矩形状の多孔質電極８ｂ，８ｃ及びそのリード部８bl，８clを形成したものである。そして、この第２ポンプセル８は、固体電解質層１８と全く同様に形成された固体電解質層２４を介して、固体電解質層２２に積層される。この結果、固体電解質層２４に穿設された矩形状の孔が第２測定室２６として機能することになる。

【００６７】そして、ヒータ１２，１４を除くＮＯｘセンサ２は、上記各部を積層して一体化した後、所定温度で焼結することにより、作製される。またこのように積層される第１ポンプセル４，Ｖｓセル６，第２ポンプセル８の積層体の両側、つまり、第１ポンプセル４と第２ポンプセル８の外側には、夫々、スペーサ２８，２９により所定間隔を開けて、ヒータ１２，１４が積層される。

【００６８】このヒータ１２，１４は、上記各固体電解質層４ａ，６ａ，…と同形状のヒータ基板１２ａ，１４ａと、各ヒータ基板１２ａ，１４ａの上記各セル４，８との対向面側に形成されたヒータ配線１２ｂ，１４ｂ及びそのリード部１２bl，１４blとからなり、スペーサ２８，２９は、このヒータ配線１２ｂ，１４ｂが、第１ポンプセル４及び第２ポンプセル８の多孔質電極４ｂ及び８ｃと、夫々、間隙を介して互いに対向するように、ヒータ配線１２ｂ，１４ｂのリード部１２bl，１４bl側に配置される。

【００６９】ヒータ基板１２ａ，１４ａは、アルミナでできており、ヒータ配線は、白金粉末にアルミナを混合してペースト状としたものを、アルミナのシートにスクリーン印刷し、焼成して形成する。なお、アルミナシートは、焼成によりヒータ基板１２ａ，１４ａ及びスペーサ２８，２９となる。そして、ヒータ１２，１４は、既に焼成された第１ポンプセル４及び第２ポンプセル８の両面からセラミック系接着剤を用いて接合され、完全なＮＯｘセンサ２となる。

【００７０】ここで、上記各固体電解質層４ａ，６ａ，…を構成する固体電解質材料としては、ジルコニアとイットリアの固溶体やジルコニアとカルシアの固溶体が代表的なものであるが、他にハフニアの固溶体、ペロブスカイト型酸化物固溶体、３価金属酸化物固溶体等も使用

できる。また各固体電解質層４ａ，６ａ，８ａの表面に設ける多孔質電極には、触媒機能を有する白金やロジウム或はその合金を使用するのが好ましい。そして、その形成方法としては、たとえば、白金粉末に固体電解質層と同じ材料の粉末を混合したものをペースト状とし、固体電解質層上にスクリーン印刷し、次いで焼結する厚膜形成方法や、蒸着による被膜形成方法が知られている。また、拡散律速層４ｄ，６ｄ，２２ｄは、細い貫通孔を有するセラミックスや多孔質セラミックスを使用するのが好ましい。

【００７１】一方、ヒータ１２，１４のヒータ配線１２ｂ，１４ｂは、セラミックスと白金又は白金合金の複合材料とし、そのリード部１２bl，１４blは、抵抗値を低下してリード部での電気ロスを低減するために、白金又は白金合金とすることが好ましい。また、ヒータ基板１２ａ，１４ａ及びスペーサ２８，２９には、アルミナ、スピネル、フォルステライト、ステアタイト、ジルコニア等を用いることができる。

【００７２】次に、図１に示すように、ＮＯｘセンサ２の第１ポンプセル４及びＶｓセル６の第１測定室２０側の多孔質電極４ｃ，６ｂは、抵抗器Ｒ１を介して接地されており、他方の多孔質電極４ｂ及び６ｃは、駆動回路４０に接続されている。駆動回路４０は、一端に定電圧ＶCPが印加され、他端が開閉スイッチＳＷ１を介してＶｓセル６の多孔質電極６ｃに接続された抵抗器Ｒ２と、－側入力端子に開閉スイッチＳＷ１を介してＶｓセル６の多孔質電極６ｃが接続され、＋側入力端子に基準電圧ＶC0が印加され、出力端子が抵抗器Ｒ０を介して第１ポンプセル４の多孔質電極４ｂに接続された差動増幅器ＡＭＰと、からなる制御部４０ａを備える。

【００７３】この制御部４０ａは、開閉スイッチＳＷ１がオン状態にあるときに次のように動作する。まず、抵抗器Ｒ２を介してＶｓセル６に一定の微小電流ｉCPを流すことにより、第１測定室２０内の酸素をＶｓセル６の多孔質電極６ｃ側に汲み込む。この多孔質電極６ｃは、固体電解質層２２により閉塞されると共に、漏出抵抗部６ｆを介して多孔質電極６ｂ側と連通していることから、微小電流ｉCPの通電により多孔質電極６ｃ内の閉塞空間は一定の酸素濃度となり、内部酸素基準源として機能する。

【００７４】またこのようにＶｓセル６の多孔質電極６ｃ側が内部酸素基準源として機能すると、Ｖｓセル６には、第１測定室２０内の酸素濃度と内部酸素基準源側の酸素濃度との比に応じた起電力が発生し、多孔質電極６ｃ側電圧Ｖｓは、第１測定室２０内の酸素濃度に応じた電圧となる。そしてこの電圧は、差動増幅器ＡＭＰに入力されることから、差動増幅器ＡＭＰからは、基準電圧ＶC0とその入力電圧との偏差（ＶC0－入力電圧）に応じた電圧が出力され、この出力電圧が、抵抗器Ｒ０を介して第１ポンプセル４の多孔質電極４ｂに印加される。

【００７５】この結果、第１ポンプセル４には、第１ポンプ電流ＩP1が流れ、この第１ポンプ電流ＩP1により、Ｖｓセル６に発生した起電力が一定電圧となるように（換言すれば第１測定室２０内の酸素濃度が一定濃度となるように）制御される。つまり、この制御部４０ａは、ポンプ電流制御手段として機能し、拡散律速層４ｄを介して第１測定室２０内に被測定ガスが流入してきた場合に、第１測定室２０内の酸素濃度が一定濃度となるように、第１測定室２０内の酸素濃度を制御する。

【００７６】なお、このように制御される第１測定室２０内の酸素濃度は、第１ポンプ電流ＩP1の通電により第１測定室２０内の被測定ガス中のＮＯｘ成分を分解してしまうことのないよう、酸素が少し存在する低酸素濃度（例えば１０００ｐｐｍ程度）となるように設定されており、この酸素濃度を決定する基準電圧ＶC0には、１００ｍＶ～２００ｍＶ程度の値が設定される。また、差動増幅器ＡＭＰの出力と多孔質電極４ｂとの間に設けられた抵抗器Ｒ０は、第１ポンプ電流ＩP1を検出するためのものであり、その両端電圧ＶIP1 は、第１ポンプ電流ＩP1の検出信号としてＥＣＵ５０に入力される。

【００７７】次に、駆動回路４０には、上記制御部４０ａに加えて、開閉スイッチＳＷ２を介してＶｓセル６の多孔質電極６ｃに接続され、多孔質電極６ｂ－６ｃ間に上記微小電流ｉCPとは逆方向に定電流を流す定電流回路４０ｂと、開閉スイッチＳＷ３を介してＶｓセル６の多孔質電極６ｃに接続され、多孔質電極６ｂ－６ｃ間に上記微小電流ｉCPと同方向に定電流を流す定電流回路４０ｃとが備えられている。

【００７８】これら各定電流回路４０ｂ，４０ｃは、Ｖｓセル６の内部抵抗ＲVSを検出するためのものである。そして、この定電流の通電によりＶｓセル６の内部抵抗ＲVSをＥＣＵ５０側で検出できるようにするために、多孔質電極６ｃ側電圧ＶｓはＥＣＵ５０に入力される。なお、各定電流回路４０ｂ，４０ｃが流す定電流は、電流方向が異なるだけで同じ電流値に設定されている。そして、この電流値は、抵抗器Ｒ２を介してＶｓセル６に供給される微小電流ｉCPよりも大きい。

【００７９】また、制御部４０ａ，定電流回路４０ｂ及び４０ｃと、Ｖｓセル６の多孔質電極６ｃとの間に夫々設けられた開閉スイッチＳＷ１～ＳＷ３は、ＥＣＵ５０からの制御信号によりオン・オフされ、酸素濃度及びＮＯｘ濃度の測定動作を行なう。通常時には、開閉スイッチＳＷ１のみがオン状態となって制御部４０ａが動作し、Ｖｓセル６の内部抵抗ＲVSを検出する場合にのみ、開閉スイッチＳＷ１がオフ状態となって、開閉スイッチＳＷ２，ＳＷ３が順にオン状態に制御される。

【００８０】一方、ＮＯｘセンサ２の第２ポンプセル８の多孔質電極８ｂ，８ｃ間には、上記検出回路４２を構成する定電圧印加手段としての抵抗器Ｒ３を介して、定電圧ＶP2が印加される。この定電圧ＶP2の印加方向は、

第２ポンプセル８において多孔質電極８ｃから８ｂ側に電流が流れて、第２測定室２６内の酸素が外部に汲み出されるように、多孔質電極８ｃ側が正極，多孔質電極８ｂ側が負極となるように設定されている。また、この定電圧VP2は、第１測定室２０から拡散律速層６ｄ，２２ｄを介して流入してくる第２測定室内の被測定ガス中のＮＯｘ成分を分解して、その酸素成分を汲み出すことができる電圧、例えば４５０ｍＶに設定されている。

【００８１】なお、抵抗器Ｒ３は、この定電圧VP2の印加によって第２ポンプセル８に流れる第２ポンプ電流ＩP2を電圧ＶIP2 に変換し、第２ポンプ電流ＩP2の検出信号としてＥＣＵ５０に入力するためのものである。このように構成された本実施例の酸素濃度・窒素酸化物濃度測定装置においては、駆動回路４０内の開閉スイッチＳＷ１をオンし、開閉スイッチＳＷ２，ＳＷ３をオフしておけば、制御部４０ａの動作によって、被測定ガスが拡散律速層（第１拡散律速層）４ｄを介して流入する第１測定室２０内の酸素濃度が一定酸素濃度に制御され、その一定酸素濃度に制御された第１測定室２０内の被測定ガスが拡散律速層（第２拡散律速層）６ｄ，２２ｄを介して第２測定室２６に流入するため、第１ポンプセル４に流れる第１ポンプ電流ＩP1は被測定ガス中の酸素濃度に応じて変化し、第２ポンプセル８に流れる第２ポンプ電流ＩP2は被測定ガス中のＮＯｘ濃度に応じて変化するようになり、ＥＣＵ５０側でこれら各電流ＩP1，ＩP2を表す検出信号ＶIP1及びＶIP2 を読み込み、所定の演算処理を実行することにより、被測定ガス中の酸素濃度及びＮＯｘ濃度を測定することができる。

【００８２】ところで、これら各濃度の測定精度を確保するには、上記各セル４，６，８の温度、特に第１測定室２０内の酸素濃度を検出するＶｓセル６の温度を、一定に制御する必要があり、このためには、ヒータ通電回路４４から各ヒータ１２，１４への通電電流量を、Ｖｓセル６の温度が目標温度となるように制御する必要がある。そこで、本実施例では、ＥＣＵ５０において、上記開閉スイッチＳＷ１～ＳＷ３のオン・オフ状態を切り換えることによりＶｓセル６の温度をその内部抵抗ＲVSから検出し、この検出した内部抵抗ＲVSが一定値（つまりＶｓセル６の温度が目標温度）となるように、ヒータ通電回路４４からヒータ１２，１４への通電量を制御する。

【００８３】以下、こうした温度制御及び濃度測定のためにＥＣＵ５０において実行される制御処理について、図３及び図４に示すフローチャートに沿って説明する。なお、図３は、酸素濃度及びＮＯｘ濃度を測定するためにＥＣＵ５０において繰返し実行される酸素濃度・ＮＯｘ濃度測定処理を表わし、図４は、Ｖｓセル６の内部抵抗ＲVSを検出してヒータ１２，１４への通電を制御するためにＥＣＵ５０において一定時間Ｔ０（例えば１sec.）毎の割込み処理として実行される内部抵抗検出処理を表わす。

【００８４】図３に示す如く、酸素濃度・ＮＯｘ濃度測定処理では、まずＳ１００（Ｓはステップを表わす）にて、当該測定装置の起動後、ヒータ１２，１４への通電によってＮＯｘセンサ２が活性化したか否かを判断することにより、ＮＯｘセンサ２が活性化するのを待つ、活性化判定処理を実行する。

【００８５】この活性化判定処理は、例えば、後述の内部抵抗検出処理にて検出されるＶｓセル６の内部抵抗ＲVSが予め設定された活性化判定値以下になったか否かを判断することにより実行される。つまり、図５に示す如く、Ｖｓセル６の内部抵抗ＲVSは、素子温度が上昇してＶｓセル６が活性化するに従い減少するので、Ｓ１００では、ヒータ１２，１４への通電開始後、Ｖｓセル６の内部抵抗ＲVSが活性化判定値以下になったか否かを判断することにより、素子温度が所定の活性化温度に達したか否かを判断するのである。

【００８６】また、当該測定装置の起動直後は、図示しない初期化処理によって、駆動回路４０内の開閉スイッチＳＷ１がオン状態、開閉スイッチＳＷ２，ＳＷ３がオフ状態に制御されるが、上記Ｓ１００の活性化判定処理によってＮＯｘセンサ２が活性化温度近傍にまで上昇するまでの間は、駆動回路４０内の差動増幅器ＡＭＰの動作は停止される。これは、ＮＯｘセンサ２が活性化していない状態では、Ｖｓセル６の内部抵抗ＲVSが大きいので、差動増幅器ＡＭＰに入力される多孔質電極６ｃ側電圧Ｖｓが高くなりすぎ、差動増幅器ＡＭＰを動作させると、第１ポンプセル４に過電流が流れてしまうからである。

【００８７】次に、Ｓ１００にてＮＯｘセンサ２が活性化したと判断されると、Ｓ１１０に移行し、検出回路４２の抵抗器Ｒ３から入力される検出信号ＶIP2 を読み込むことにより、第２ポンプ電流ＩP2を検出する、窒素酸化物濃度測定手段としての処理を実行する。また続くＳ１２０では、駆動回路４０の抵抗器Ｒ０から入力される検出信号ＶIP1 を読み込むことにより、第１ポンプ電流ＩP1を検出する、酸素濃度測定手段としての処理を実行する。

【００８８】そして、続くＳ１３０では、その検出した第１ポンプ電流ＩP1に基づき、第２ポンプ電流ＩP2に対する基準補正量を算出する。即ち、本実施例では、上記駆動回路４０によるポンプ電流制御によって、第１測定室２０内の被測定ガス中のＮＯｘ成分を分解してしまうことのないよう、第１測定室２０内の酸素濃度を低酸素濃度に制御していることから、第２測定室２６には、被測定ガス中のＮＯｘだけでなく酸素も流入する。従って、第２ポンプ電流ＩP2は、被測定ガス中のＮＯｘ濃度に対応して変化するものの、被測定ガス中の酸素濃度の影響も受ける。図６は、ＮＯｘを含まない試験用ガスを被測定ガスとして当該装置を動作させた際の第１ポンプ

電流ＩP1と第２ポンプ電流ＩP2の測定結果の一例を表わしているが、この図からも明らかなように、第１ポンプ電流ＩP1は被測定ガス中の酸素濃度に対応して一定の傾きで変化し、第２ポンプ電流ＩP2も被測定ガス中の酸素濃度の影響を受けて変化する。

【００８９】そこで本実施例では、第２ポンプ電流ＩP2を被測定ガス中のＮＯｘ濃度のみに対応させるために、上記のようにＮＯｘを含まない被測定ガスを測定した際に得られる酸素濃度に対応した第２ポンプ電流ＩP2の値を、第２ポンプ電流ＩP2補正のためのオフセット値としてＲＯＭ等の記憶媒体に予め記憶しておき、第１ポンプ電流ＩP1から被測定ガス中の酸素濃度を検出して、この酸素濃度に対応したオフセット値を、予め記憶したオフセット値データの中から読み出し、上記基準補正量として設定するようにしているのである。

【００９０】なお、この基準補正量を実際に算出する際には、第１ポンプ電流ＩP1に対応してオフセット値（つまり基準補正量）を記憶したマップが使用され、第１ポンプ電流ＩP1をパラメータとしてこのマップを検索することにより、第１ポンプ電流ＩP1から直接基準補正量を求める。

【００９１】こうして基準補正量が算出されると、今度は、Ｓ１４０に移行し、後述の内部抵抗検出処理で得られたＶｓセル６の内部抵抗ＲVSを読み込む。そして、続くＳ１５０では、この読み込んだ内部抵抗ＲVSに基づき、第２ポンプ電流ＩP2に対する温度補正量を算出する。

【００９２】つまり、本実施例では、後述の内部抵抗検出処理において、Ｖｓセル６の内部抵抗ＲVSを検出して、その内部抵抗ＲVSが所定値となるように（換言すればＮＯｘセンサ２の温度が所定の目標温度となるように）、ヒータ１２，１４への通電を制御するが、被測定ガスの温度が急変したような場合には、温度制御を被測定ガスの温度変化に追従させることができず、ＮＯｘセンサ２の温度が被測定ガスの温度変化によって変化することがある。

【００９３】例えば、図７は、本実施例の測定装置を用いて内燃機関の排気中のＮＯｘ濃度を測定すべく、ＮＯｘセンサ２を内燃機関の排気管に取り付け、当該装置を動作させた場合の、ＮＯｘセンサ２の温度変化を測定した測定結果の一例を表わしている。この図から明らかなように、本実施例の測定装置では、後述の温度制御を行なっているにもかかわらず、内燃機関の加速時に吸入空気量の増大に伴い排気温度が一時的に低下したり、内燃機関の減速時に吸入空気量の減少に伴い排気温度が一時的に上昇したりすると、ＮＯｘセンサ２がその温度変化の影響を受けて、第１ポンプ電流ＩP1，第２ポンプ電流ＩP2が共に変化してしまい、特に第２ポンプ電流ＩP2は、安定状態に戻るまでに約１分もの時間を要することになる。なお、これは、第１ポンプ電流ＩP2が排気温度の影響を受けることにより第１測定室２０内の酸素濃度が目標濃度から一旦ずれると、その後、その酸素濃度を目標濃度に戻すのに時間がかかるためである。

【００９４】そこで、本実施例では、被測定ガスの温度が急変しても、第２ポンプ電流ＩP2からＮＯｘ濃度を正確に測定できるようにするために、Ｖｓセル６の内部抵抗ＲVSからＶｓセル６の温度を求め、例えば図８に如き温度補正量算出用のマップを用いて、第２ポンプ電流ＩP2に対する温度補正量を求めるようにしているのである。

【００９５】なお、図８に示すマップは、Ｖｓセル６の素子温度から温度補正量を求めるように設定されているが、Ｖｓセル６の内部抵抗ＲVSをパラメータとする温度補正量算出用のマップを予め設定しておけば、内部抵抗ＲVSを温度に換算することなく、内部抵抗ＲVSから直接温度補正量を求めることができる。また、例えば、素子温度と目標温度（図８では目標温度が８５０℃となっている）との偏差をパラメータとするマップを予め設定しておき、素子温度の目標温度からのずれ（偏差）から温度補正量を求めるようにしてもよく、或は、内部抵抗ＲVSと目標温度に対応した目標抵抗値との偏差をパラメータとするマップを予め設定しておき、内部抵抗ＲVSの目標抵抗値からのずれ（偏差）から温度補正量を求めるようにしてもよい。

【００９６】次に、Ｓ１５０にて温度補正量が算出されると、Ｓ１６０に移行し、Ｓ１１０で検出した第２ポンプ電流ＩP2に基準補正量及び温度補正量を加算することにより、第２ポンプ電流ＩP2を補正する。そして、続くＳ１７０では、この補正後の第２ポンプ電流ＩP2をＮＯｘ濃度の測定結果として外部装置（エンジン制御装置等）に出力する。

【００９７】また次に、Ｓ１８０では、Ｓ１４０で読み込んだ内部抵抗ＲVSに基づき、第１ポンプ電流ＩP1に対する温度補正量を算出する。そして、続くＳ１９０では、この算出した温度補正量を用いて、Ｓ１２０で検出した第１ポンプ電流ＩP1を補正し、続くＳ２００にて、この補正後の第１ポンプ電流ＩP1を酸素濃度の測定結果として外部装置に出力し、再度Ｓ１１０に移行する。

【００９８】なお、Ｓ１８０及びＳ１９０の処理は、第１ポンプ電流ＩP1を、ＮＯｘセンサ２の温度変化に影響されることなく、被測定ガス中の酸素濃度に対応させるための処理であり、Ｓ１８０では、上記Ｓ１５０と同様、予め設定されたマップを用いて第１ポンプ電流ＩP1に対する温度補正量を算出する。

【００９９】そして、本実施例では、ＮＯｘ濃度に対応した第２ポンプ電流ＩP2と酸素濃度に対応した第１ポンプ電流ＩP1とを、夫々、Ｖｓセル６の温度に応じて補正するために実行されるＳ１５０，Ｓ１６０，Ｓ１８０，Ｓ１９０の処理が、本発明の補正手段に相当する。

【０１００】ここで、本実施例では、上記酸素濃度・Ｎ

Ｏｘ濃度測定処理において、第１ポンプ電流ＩP1に基づき被測定ガス中の酸素濃度に応じて第２ポンプ電流ＩP2を補正するための基準補正量と、Ｖｓセル６の温度に応じて第２ポンプ電流ＩP2を補正するための温度補正量とを個々に求めて、第２ポンプ電流ＩP2を補正するものとして説明したが、例えば、Ｖｓセル６の温度毎に、基準補正量算出用のマップを設定しておき、Ｖｓセル６の温度に応じて、基準補正量の算出に使用するマップを切り換えることにより、被測定ガス中の酸素濃度とＶｓセル６の温度とに応じて第２ポンプ電流ＩP2を補正するための補正量を求めるようにしてもよく、或は、第１ポンプ電流ＩP1とＶｓセル６の温度（又は内部抵抗ＲVS）をパラメータとする補正量算出用の２次元マップを予め設定しておき、このマップを用いて第２ポンプ電流ＩP2に対する補正量を求めるようにしてもよい。

【０１０１】次に、図４に示す内部抵抗検出処理を説明する。なお、この内部抵抗検出処理は、単にＶｓセル６の内部抵抗ＲVSを検出する温度検出手段としての機能だけでなく、その検出結果からヒータ通電回路４４を介してヒータ１２，１４への通電電流量を制御するヒータ通電制御手段としての機能も有する。

【０１０２】図４に示す如く、この処理が開始されると、Ｓ２１０にて、Ｖｓセル６の多孔質電極６ｃ側電圧Ｖｓを読み込み、これをＶｓセル６の基本検出電圧VS1として設定する。そして、続くＳ２２０では、濃度測定のためにオン状態にされていた開閉スイッチＳＷ１をオフし、定電流回路４０ｂに接続された開閉スイッチＳＷ２をオンすることにより、Ｖｓセル６に微小電流ｉCPとは逆方向（つまり今まで内部酸素基準源となっていた閉塞空間側から第１測定室２０側に酸素を汲み込む方向）に定電流を流す。

【０１０３】また、続くＳ２３０では、当該検出処理の起動後、所定時間Ｔ１（例えば６０μsec.）が経過したか否かを判断することにより、所定時間Ｔ１が経過するのを待ち、所定時間Ｔ１が経過すると、Ｓ２４０にて、Ｖｓセル６の多孔質電極６ｃ側電圧Ｖｓを読み込み、これをＶｓセル６の抵抗検出電圧VS2として設定する。

【０１０４】こうして抵抗検出電圧VS2を設定すると、Ｓ２５０に移行して、当該検出処理の起動後、所定時間Ｔ２（例えば１００μsec.）が経過したか否かを判断することにより、所定時間Ｔ２が経過するのを待ち、所定時間Ｔ２が経過すると、Ｓ２６０にて、当該検出処理の起動後、一定時間Ｔ２の間オン状態となっていた開閉スイッチＳＷ２をオフし、定電流回路４０ｃに接続された開閉スイッチＳＷ３をオンすることにより、Ｖｓセル６に微小電流ｉCPと同方向（つまり第１測定室２０内の酸素を閉塞空間側に汲み込む方向）に定電流を流す。

【０１０５】このように開閉スイッチＳＷ３をオンすると、Ｓ２７０に移行して、今度は、当該検出処理の起動後、所定時間Ｔ３（例えば２００μsec.）が経過したか否かを判断することにより、所定時間Ｔ３が経過するのを待ち、所定時間Ｔ３が経過すると、Ｓ２８０にて、開閉スイッチＳＷ３をオフする。この結果、駆動回路４０内の開閉スイッチＳＷ１～ＳＷ３は全てオフ状態となる。

【０１０６】そして、続くＳ２９０では、当該検出処理の起動直後に設定した基本検出電圧VS1と所定時間Ｔ１経過後に設定した抵抗検出電圧VS2との偏差△Ｖｓ（＝VS1－VS2）を求め、Ｓ３００にて、この偏差△Ｖｓから Ｖｓセル６の内部抵抗ＲVSを算出し、続くＳ３１０に移行する。なお、本実施例における内部抵抗ＲVSの算出手法については、後に詳しく説明する。

【０１０７】Ｓ３１０では、上記算出したＶｓセル６の内部抵抗ＲVSと目標値との偏差、又は内部抵抗ＲVSから得られるＶｓセル６の温度と目標温度との偏差に基づき、ヒータ１２，１４への通電電流量を増・減するための制御信号（ヒータ制御信号）をヒータ通電回路４４に出力し、ヒータ通電回路４４からヒータ１２，１４に供給される電流量を制御する、ヒータ通電制御手段としての処理を実行する。

【０１０８】なお、このヒータ通電制御では、ヒータ通電回路４４を、ヒータ１２，１４への通電・非通電を高速に切り換え可能なスイッチング回路から構成した場合には、その通電・非通電の切り換えを行なう駆動パルスのデューティ比を制御するようにすればよく、また、ヒータ通電回路４４を、ヒータ１２，１４への出力電圧を制御可能な電圧制御回路から構成した場合には、ＥＣＵ５０からのヒータ制御信号に基づき電圧を増減するようにすればよい。

【０１０９】そしてこのようにヒータ制御信号を出力すると、今度は、Ｓ３２０に移行して、当該検出処理の起動後、所定時間Ｔ４（例えば５００μsec.）が経過したか否かを判断することにより、所定時間Ｔ４が経過するのを待ち、所定時間Ｔ４が経過すると、Ｓ３３０にて、当該検出処理の起動後、一定時間Ｔ４の間オフ状態となっていた開閉スイッチＳＷ１をオンして、当該検出処理を終了することにより、酸素濃度及びＮＯｘ濃度の測定動作を再開させる。

【０１１０】以上説明した内部抵抗検出処理では、図９に示す如く、処理が開始されると（時点ｔ１）、駆動回路４０内の開閉スイッチＳＷ１をオフして、Ｖｓセル６への微小電流ｉCPの通電及びポンプ電流制御を停止させると共に、開閉スイッチＳＷ２をオンして、Ｖｓセル６に微小電流ｉCPとは逆方向に定電流を流す。そして、その後一定時間Ｔ１が経過すると（時点ｔ２）、そのときの多孔質電極６ｃ側電圧Ｖｓを抵抗検出電圧VS2として設定し、この抵抗検出電圧VS2と当該検出処理起動時の多孔質電極６ｃ側電圧Ｖｓ（つまり基本検出電圧VS1）との偏差△ＶｓからＶｓセル６の内部抵抗ＲVSを検出する。以下、この理由について説明する。

【０１１１】まず、Ｖｓセル６に内部抵抗検出用の定電流を流した場合、Ｖｓセル６の多孔質電極６ｃ側電圧Ｖｓは、Ｖｓセル６の内部抵抗ＲVSだけでなく、各電極６ｂ，６ｃ側の酸素濃度の比に応じて発生する起電力によっても変化する。そこで、本実施例では、内部抵抗検出用の多孔質電極６ｃ側電圧Ｖｓがこの起電力の影響を受け難くするために、微小電流ｉCPよりも大きな電流を流して、Ｖｓセル６の内部抵抗ＲVSによる電圧降下が大きくなるようにしている。

【０１１２】また、Ｖｓセル６の各電極６ｂ，６ｃ側の酸素濃度は、ポンプ電流制御と微小電流ｉCPの通電とにより、夫々、略一定になるため、Ｖｓセル６の起電力も略一定になる。従って、Ｖｓセル６に定電流を流して、そのときの多孔質電極６ｃ側電圧Ｖｓ（即ちVS2）を検出するようにしても、この電圧値からＶｓセル６の内部抵抗ＲVSを略正確に求めることができる。

【０１１３】しかし、より厳密には、第１測定室２０内の酸素濃度は、ポンプ電流のフィードバック制御によって制御されるため、制御系の応答遅れ等によって変動しており、一定濃度に固定されるものではない。また、第１測定室２０内の酸素濃度は、ＮＯｘセンサ２の温度によっても変化する。従って、Ｖｓセル６に内部抵抗ＲVS検出用の定電流を流すことにより検出した電圧Ｖｓから内部抵抗ＲVSを求めた場合には、内部抵抗ＲVSに若干ではあるが、誤差が生じてしまうことになる。

【０１１４】そこで、本実施例では、Ｖｓセル６の内部抵抗ＲVS，延いては素子温度をより正確に検出できるようにするために、Ｖｓセル６に内部抵抗ＲVS検出用の定電流を流してから所定時間（例えば６０μsec.）経過するまでの間の多孔質電極６ｃ側電圧Ｖｓの変化量（偏差△Ｖｓ）を検出し、この偏差△Ｖｓから内部抵抗ＲVSを求めることにより、第１測定室２０内の酸素濃度が目標濃度からずれている場合であっても、Ｖｓセル６の内部抵抗ＲVS，延いては素子温度を正確に求めることができるようにしているのである。

【０１１５】なお、この内部抵抗ＲVSを算出するに当っては、偏差△Ｖｓに対応して内部抵抗ＲVSを記憶したマップを予め設定しておき、このマップを用いて内部抵抗ＲVSを算出するようにすればよい。また次に、本実施例の内部抵抗検出処理では、起動後、一定時間Ｔ１が経過して、抵抗検出電圧VS2を設定すると（時点ｔ２）、その後更に所定時間（例えば４０μsec.）が経過して、当該検出処理起動後の経過時間がＴ２に達した時点ｔ３で、駆動回路４０の開閉スイッチＳＷ２をオフし、開閉スイッチＳＷ３をオンすることにより、Ｖｓセル６に微小電流ｉCPと同方向に定電流を流し、更に、一定時間（例えば１００μsec.）が経過して、当該検出処理起動後の経過時間がＴ３に達すると（時点ｔ４）、開閉スイッチＳＷ３をオフする。

【０１１６】この結果、本実施例においては、内部抵抗ＲVSの検出のためにＶｓセル６の多孔質電極６ｃ側の閉塞空間から汲み出した酸素を速やかに戻すことができ、また、ｉCPとは逆方向に電流を流したことによって、変化したＶｓセル６の内部分極状態を元に戻すことができるので、多孔質電極６ｃ側の閉塞空間を内部基準酸素源として速やかに機能させることができ、また、Ｖｓセル６を酸素濃度測定セルとして速やかに機能させることができる。従って、当該処理起動後、濃度測定の動作に入るまでの時間Ｔ４を、例えば５００μsec.というように、極めて短い時間にすることができ、酸素濃度及びＮＯｘ濃度の測定に影響を与えることなく、Ｖｓセル６の内部抵抗ＲVSを高精度に検出することが可能になる。

【０１１７】以上説明したように、本実施例の酸素濃度・窒素酸化物濃度測定装置においては、第１測定室２０の酸素濃度を検出するＶｓセル６の内部抵抗ＲVSからＮＯｘセンサ２の温度を検出し、この温度が目標温度（例えば８５０℃）となるように、ヒータ１２，１４への通電電流量を制御し、しかも、検出した内部抵抗ＲVS又はこの内部抵抗ＲVSから得られる素子温度が目標値から外れた場合には、その偏差に応じた温度補正量にて、ＮＯｘ濃度及び酸素濃度の測定結果を表わす第２ポンプ電流ＩP2及び第１ポンプ電流ＩP1を夫々補正することにより、ＮＯｘ濃度及び酸素濃度の測定結果を温度補償するようにされている。このため、本実施例の酸素濃度・窒素酸化物濃度測定装置によれば、ＮＯｘセンサ２の温度に影響されることなく、酸素濃度及びＮＯｘ濃度を常に高精度に検出することができる。

【０１１８】また特に、本実施例では、ＮＯｘセンサ２が、第１ポンプセル４，Ｖｓセル６，第２ポンプセル８の順に積層されると共に、その積層方向両側に、ヒータ１２，１４が積層されており、しかも、その積層方向からＮＯｘセンサ２を投影したときに、拡散律速層４ｄと拡散律速層６ｄ，２２ｄとが重なり、これら各拡散律速層を略中心位置で挟むように、ヒータ１２，１４のヒータ配線１２ｂ，１４ｂが配置されている。従って、本実施例では、こうしたＮＯｘセンサ２の構造によって、ヒータ１２，１４を用いて各セル４～８を効率良く加熱することができ、また、各拡散律速層を介して第１測定室２０及び第２測定室２６内に流入する被測定ガスも効率良く加熱することができるようになる。このため、本実施例によれば、Ｖｓセル６の温度を制御することにより、ＮＯｘセンサ２を構成する各セルの温度をより確実に目標温度に制御することが可能になり、酸素濃度及びＮＯｘ濃度の測定精度を向上できる。

【０１１９】なお、本実施例では、素子温度の測定中は第１ポンプセル４への電流制御を停止するようにしたが、例えば、差動増幅器ＡＭＰへの入力段にサンプルアンドホールド回路を設けて、素子温度の測定開始前の多孔質電極６ｃ側電圧Ｖｓをサンプルホールドするようにすれば、素子温度の測定中も、そのサンプルホールドし

た電圧値により差動増幅器ＡＭＰを動作させて、第１ポンプセル４の電流制御を持続させるようにすることもできる。

【図面の簡単な説明】

【図１】　実施例の酸素濃度・窒素酸化物濃度測定装置全体の構成を表わす概略構成図である。

【図２】　実施例のＮＯｘセンサの構成を表わす分解斜視図である。

【図３】　実施例のＥＣＵにおいて繰返し実行される酸素濃度・ＮＯｘ濃度測定処理を表わすフローチャートである。

【図４】　実施例のＥＣＵにおいて所定時間毎の割込み処理として実行される内部抵抗検出処理を表わすフローチャートである。

【図５】　酸素濃度測定セルの内部抵抗と素子温度との関係を表わすグラフである。

【図６】　ＮＯｘを含まない被測定ガスの酸素濃度と第１ポンプ電流及び第２ポンプ電流との関係を表わすグラフである。

【図７】　内燃機関の加・減速時の排気温度変化によって生じる第１ポンプ電流及び第２ポンプ電流の変化を表わすタイムチャートである。

【図８】　第２ポンプ電流に対する温度補正量を求める＊

＊際に使用されるマップの一例を表わすグラフである。

【図９】　図４に示した内部抵抗検出処理の動作を説明するタイムチャートである。

【図１０】　全領域空燃比センサのおいてポンプ電流制御により得られる酸素濃度の温度特性を説明する説明図である。

【符号の説明】

２…ＮＯｘセンサ　４…第１ポンプセル　６…Ｖｓセル

８…第２ポンプセル　１２，１４…ヒータ

４ａ，６ａ，８ａ，１８，２２，２４…固体電解質層

４ｂ，４ｃ，６ｂ，６ｃ，８ｂ，８ｃ…多孔質電極

４ｄ，６ｄ，２２ｄ…拡散律速層　６ｆ…漏出抵抗部

１２ａ，１４ａ…ヒータ基板　１２ｂ，１４ｂ…ヒータ配線

２０…第１測定室　２６…第２測定室　４０…駆動回路

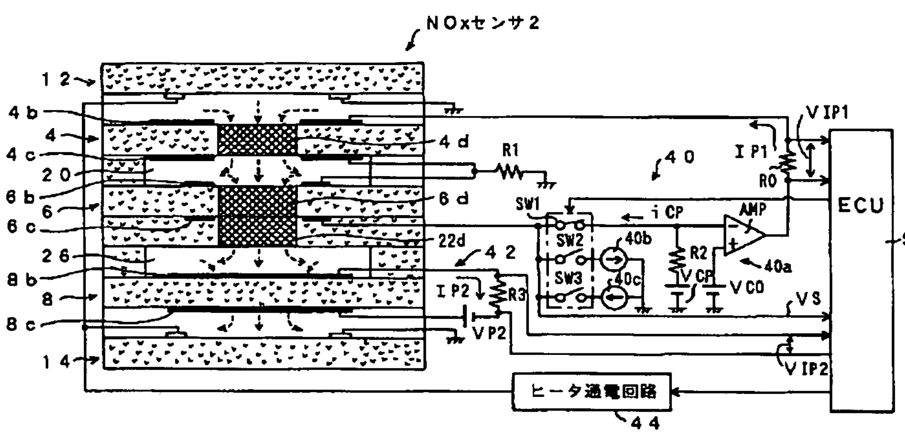
４０ａ…制御部　４０ｂ，４０ｃ…定電流回路　４２…検出回路

４４…ヒータ通電回路　ＡＭＰ…差動増幅器

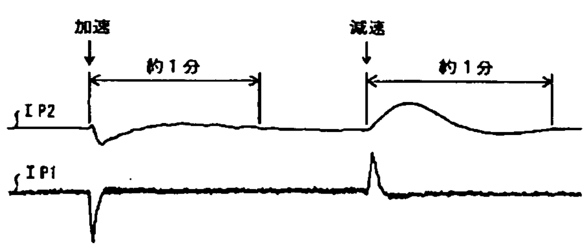
Ｒ０，Ｒ１，Ｒ２，Ｒ３…抵抗器

ＳＷ１，ＳＷ２，ＳＷ３…開閉スイッチ

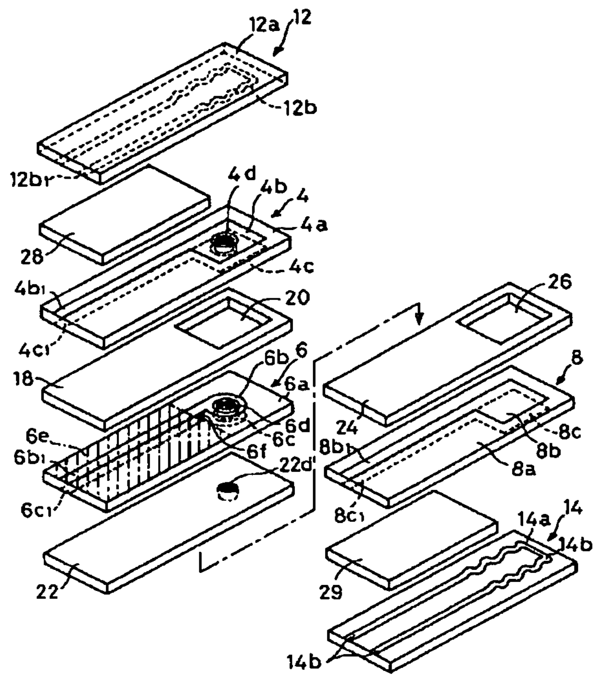
【図１】



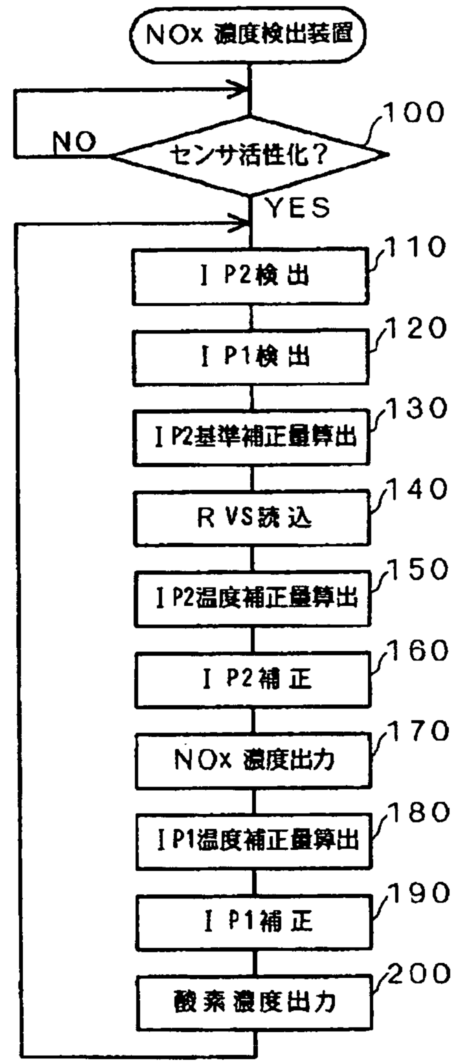
【図７】



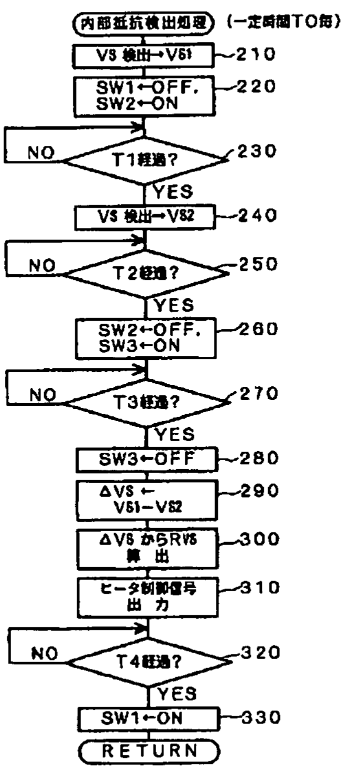
【図２】



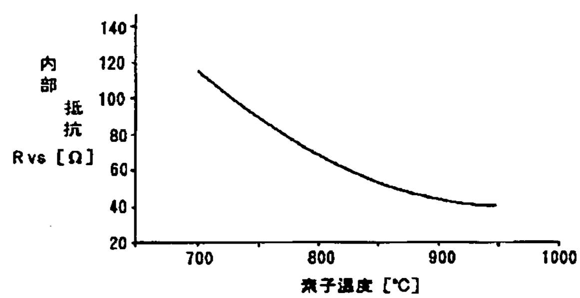
【図３】


NOx 濃度検出装置
センサ活性化？
NO
YES
100
I P2検出
110
I P1検出
120
I P2基準補正量算出
130
R VS読込
140
I P2温度補正量算出
150
I P2補正
160
NOx 濃度出力
170
I P1温度補正量算出
180
I P1補正
190
酸素濃度出力
200

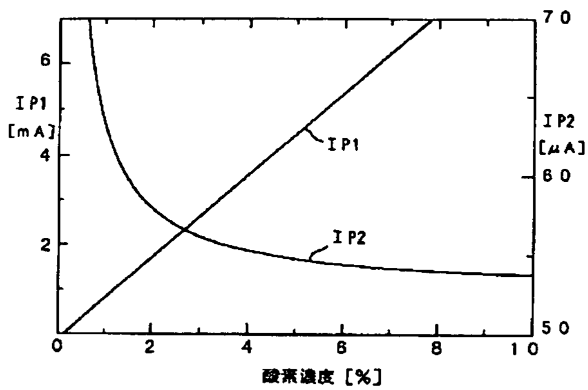
【図４】


内部抵抗検出処理
(一定時間TO毎)
VS 検出→VS1
210
SW1←OFF,
SW2←ON
220
T1経過？
230
NO
YES
VS 検出→VS2
240
T2経過？
250
SW2←OFF,
SW3←ON
260
T3経過？
270
SW3←OFF
280
ΔVS ←
VS1−VS2
290
ΔVS からRVS
算出
300
ヒータ制御信号
出力
310
T4経過？
320
SW1←ON
330
RETURN

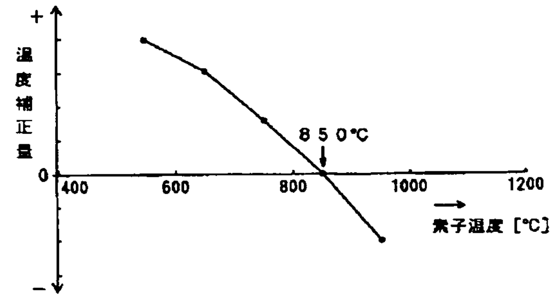
【図５】


内部抵抗
Rvs [Ω]
140
120
100
80
60
40
20
700
800
900
1000
素子温度 [℃]

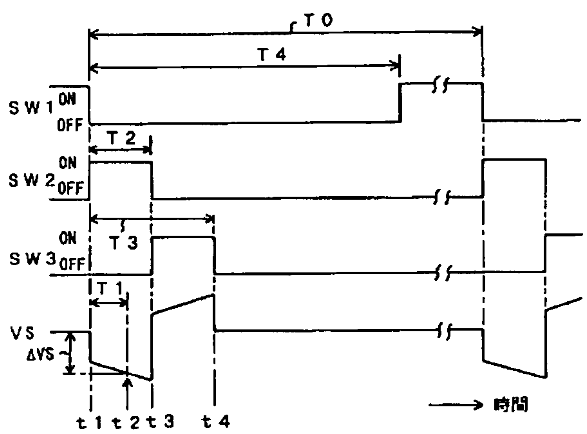
【図６】


IP1
[mA]
IP2
[μA]
70
60
50
6
4
2
0
2
4
6
8
10
IP1
IP2
酸素濃度[%]

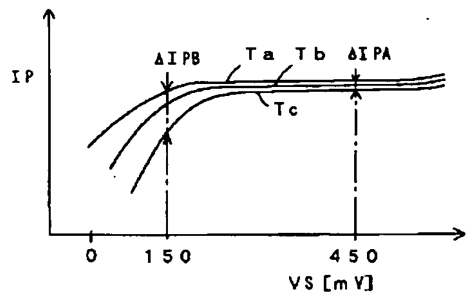
【図８】


+
－
温度補正量
0
400
600
800
1000
1200
850℃
素子温度[℃]

【図９】


T0
T4
SW1
ON
OFF
T2
SW2
ON
OFF
T3
SW3
ON
OFF
T1
VS
ΔVS
t1 t2 t3 t4
時間

【図１０】


IP
ΔIPB
Ta
Tb
ΔIPA
Tc
0
150
450
VS [mV]